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XVIII

FOSSIL CHITONS OF WESTERN NORTH AMERICA.

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Introduction

Begun primarily as a simple record of the occurrence of chitons in the later Tertiary and Quaternary deposits of southern California, the unexpected accretion of altogether unusual amounts of material from ever-increasing sources has necessarily impelled a widening in scope of the work in hand until it is now frankly offered as a monographic survey of the known fossil Polyplacophora of western North America.

Chitons are not generally considered as having much importance as fossils, and, taking the world as a field, surprisingly few fossil species or even specimens have been brought to light and recorded. Yet there are reasons for believing that the members of this group, when they do occur, have an intrinsic value as paleontologic criteria rather above that of most groups of Mollusca. At any rate, it is not altogether well to neglect them. The chief reasons for believing that the chitons furnish relatively conservative, and therefore correspondingly dependable, indices are: firstly, that on the Pacific Coast of North America this group is by no means of rare occurrence in the later fossiliferous horizons, as has been more or less implicitly assumed in the past, but attains a development paralleled only by the remarkable amplification of the entire class in

the recent fauna of the same region; secondly, that both individually and in associations of species, these animals are remarkably definite in their latitudinal distribution; and thirdly, that this definiteness of geographical area inhabited extends even more sharply to station as well. The bathymetric range of most chitons is curiously narrow.

It is accordingly the writer's belief that far from being justly negligible, it is possible that the chitons will prove among the best criteria for determining the age and relationships of any formation in which they can be found with appreciable frequency. It is in this connection, as well as the inherent interest of one of our most characteristic, yet strangely neglected, faunal groups, that this paper is chiefly of consequence.

ACKNOWLEDGMENTS

Among the many who have furnished material aid during the prosecution of this work, and to all of whom I wish gratefully to acknowledge my due indebtedness, I am under chief obligation to Mr. and Mrs. Emery P. Chace of the Lorquin Natural History Club of Los Angeles. They have been both assiduous and successful in the search for additional material and new horizons in the field, have been unfailingly generous and self-sacrificing in the disposition of their specimens, and have managed to maintain an enthusiastic interest throughout the course of the investigations.

Scarcely less credit belongs to Dr. Frank C. Clark of Santa Monica and Los Angeles, who has ransacked his wonderful material from the Pleistocene of his vicinity that no possible specimen might escape examination, and to Mr. and Mrs. Frank Stephens of San Diego, whom I must thank for many valuable specimens, as well as field data, which in some cases have cost them considerable trouble to secure.

To Dr. William E. Ritter and the Scripps Institution for Biological Research, under whose auspices the work was begun and in large part carried on, I am indebted for aid of a nature which has very much expedited the progress of the work.

Dr. Bruce L. Clark of the University of California has been instrumental in securing me material for study, including the interesting series of specimens from Vancouver Island Oligo-

cene, and has been unfailingly helpful throughout in evincing interest and giving useful advice.

Acknowledgments are further due to Dr. James Perrin Smith and Mr. and Mrs. T. S. Oldroyd of the Department of Geology at Stanford University, for the loan of the very considerable fossil chiton material in the collections under their care; and to Dr. Barton Warren Evermann, Director of the California Academy of Sciences, Dr. Roy E. Dickerson, formerly of the same institution, and Dr. Ralph Arnold of Los Angeles, for courtesies of various sorts.

Thanks are due to Miss Mary J. Rathbun of the United States National Museum for the identification of some crab claws from the Pleistocene of Point Loma, and to Dr. Henry A. Pilsbry of the Academy of Natural Sciences of Philadelphia for determining some barnacle fragments from the same locality.

Finally, I must not omit mention of my indebtedness to Mr. Herbert J. Powell of Redlands, for his patient work on the drawings used in the accompanying plates. Even though it must be said that we have found that stipple is not, on the whole, the most satisfactory method of illustrating chitons, his results in this direction have added very materially to the completeness and practical working value of this paper.

Review of Literature

The literature of Pacific Coast fossil chitons is of scanty extent. It is so scattered that an exhaustive compilation has been rendered correspondingly difficult. Nevertheless, and in spite of insufficient library facilities, the following survey is believed to be reasonably complete.

The first published mention of the presence of chiton remains in any geological formation within the area under consideration, is, so far as the writer has been able to discover, that of Dr. J. G. Cooper in his "Catalogue of Californian Fossils" ('88, p. 237, 244). He records:

> *Cryptochiton stelleri* (Middendorff)—*Pleistocene* San Diego.
>
> *Ischnochiton magdalensis* (Hinds)—*Pleistocene* Santa Barbara.

In the succeeding year, Orcutt ('89, p. 71) reports the finding of "Chiton (valves)" from "about two miles south of Ocean Beach [San Diego], near the top of the cliff."

Ashley ('95, p. 327, 343) records *"Cryptochiton* c.f. *stelleri"* from Purissima in San Mateo County, and *Ischnochiton regularis* from the "Pliocene" (Pleistocene) at San Pedro.

I find nothing further until the publication of Arnold's great monograph on the Tertiary and Quaternary of the San Pedro region (:03, p. 15, 19, 28, 40, 42, 68, 85, 342-343), where the following three fossil species are recognized:

Ischnochiton regularis (Cpr.)—*Pleistocene* San Pedro.
Cryptochiton stelleri (Midd.)—*Pliocene* Deadman Island.
Pleistocene " "
Mopalia ciliata (Sby.) [=*muscosa* of this work]—
Pleistocene San Pedro.

The same three species are also listed by Arnold three years later in his monograph of the Californian Tertiary and Quaternary Pectens (:06, p. 31, 35, 36).

Oldroyd (:14, p. 81) records *Ischnochiton conspicuus* Cpr. from the Pleistocene of Signal Hill, Long Beach, California.

Moody (:16, p. 42) records an undetermined chiton from the Fernando Formation of the Pliocene at Los Angeles, California.

Chace (:16, p. 71-72) lists the following from the Pleistocene of Deadman Island, California, thus increasing the number of chiton species up to this time identified as fossils to seven:

Katherina tunicata "Sby."
Ischnochiton conspicuus Carpenter.
Mopalia hindsii "(Sby.) Reeve."

The next year the same writer materially increased the list by reporting the following from the Pleistocene of Santa Monica, California (:17, p. 30):

Ischnochiton acrior Carpenter
" *conspicuus* Carpenter
" *clathratus* (Reeve) [=*sanctæmonicæ* Berry of the present paper]

Callistochiton crassicostatus Pilsbry
" *palmulatus* Carpenter
" " var. *mirabilis* Pilsbry. [These both given as *C. p. mirabilis* in the present paper]
Trachydermon denticus Carpenter [=*Mopalia acuta* (Carpenter) of the present paper]
Mopaliidæ sp.

B. L. Clark (:18, p. 191) records and figures an undetermined chiton valve from the San Lorenzo Oligocene near Walnut Creek, Contra Costa County, California.

The most extensive published list of fossil chitons from any part of the area under study is that of E. P. and E. M. Chace (:19, p. 42-43), based on determinations made by the present writer on material which is part of that forming the subject of this report. The exposure from which the material was obtained has been termed by Mr. and Mrs. Chace, "The Chiton Bed," and is situated at Point Fermin, Los Angeles County, California. They list the following species:

Tonicella lineata (Wood)
Cyanoplax hartwegii (Carpenter)
Nuttallina cf. *fluxa* (Carpenter) [=*N. californica* (Nuttall) of the present paper]
Mopalia ciliata (Sowerby)
" *lignosa* (Gould)
" *muscosa* (Gould)
Placiphorella velata Carpenter
Chætopleura gemmea Carpenter
Ischnochiton magdalenensis (Hinds)
" *cooperi* Carpenter
Callistochiton crassicostatus Pilsbry
" *decoratus* Carpenter

This brings the total number of fossil species hitherto recorded from our area to 21, all from the Pleistocene and Pliocene, with an uncertain representative from the Oligocene. In the present work the number is increased to 33 which are clearly distinct, besides two or three uncertain ones. Of these one only is of Oligocene age; a few are Pliocene; most are from the Pleistocene formations. No chitons of any description ap-

pear to have been discovered to date in the Miocene[1] or in the West American formations earlier than the Sooke Formation of the Oligocene. As the number of described recent species from the adjacent coasts is in excess of one hundred, the occurrence of most of which in the Pleistocene at least is undoubtedly possible, it is evident that scarcely more than a beginning has been made with the fossils.

MATERIAL

The material utilized in the preparation of this survey is believed to include most of the extant specimens. It comprises some 1065 valves, obtained chiefly from the following sources:

1. The Delos and Ralph Arnold collections, the Arnold and Hannibal Oligocene collection, and the Oldroyd collection —all now contained in the museum of the department of geology, Leland Stanford Junior University.
2. The museum of the California Academy of Sciences.
3. The museum of the department of paleontology, University of California.
4. The private collection of S. S. Berry.
5. The private collection of Mr. and Mrs. E. P. Chace, Los Angeles, California.
6. The private collection of Dr. Frank C. Clark, Santa Monica, California.
7. The Mrs. Kate Stephens collection, now contained in the museum of the San Diego Society of Natural History.

Much of the more critical material studied from the private collections mentioned has, through the generosity of their owners, been assembled permanently in the author's study collection.

The Chace collection has been of principal importance, as it is not only extensive, but representative of several exposures, some of them apparently owing their initial discovery and exploration to Mr. and Mrs. Chace, while the specimens as a rule are accompanied by the most careful data.

Dr. F. C. Clark's enormous material from the Santa Monica Pleistocene is probably the most complete that has been taken

[1] cf. especially the check-lists of the Miocene Fauna in California given by J. P. Smith in Proceedings California Academy of Sciences, (4), v. 3, p. 170-182, April, 1912. I know of no additions since that time which would concern us here.

from any single geological horizon within our area, and so is of hardly less consequence.

The Stephens collection does not contain so many specimens as the others, but these are representative of various important formations in the vicinity of San Diego.

The Arnold and Oldroyd collections are remarkably rich in their representation of species, but the maximum value of much of this material has been lost by inadequate station labeling. Evidently, also, there has been some mixture of specimens. However, the material is included in this report both for the sake of completeness and because many of the specimens had already been utilized for purposes of illustration before the better ones came to hand.

In the Arnold and Hannibal collection and that of the California Academy of Sciences are specimens of the interesting new chiton described from the Vancouver Island Oligocene. The museum of the latter institution has also furnished specimens from one of the Point Loma Pleistocene exposures.

The University of California collection contains mainly recent chitons, but some of these have been valuable for purposes of comparison.

Summary of Stations

OLIGOCENE

Sooke Formation:

1. Sea cliff between mouths of Muir and Kirby creeks, Vancouver Island, British Columbia (Harold Hannibal, N. P. 129; Cal. Acad. Sci. Loc. 231).

It is through the kindness of Dr. B. L. Clark, who is engaged in working up the fauna of this formation, that the single chiton species obtained can be included here. It is

Oligochiton lioplax Berry, new species

San Lorenzo Formation:

2. Walnut Creek, Contra Costa County, California (B. L. Clark).

I have had no material from this horizon, but Clark (:18, p. 191, pl. 14, f. 2) records and figures the valve of an undetermined chitonid species. Unfortunately the original speci-

men has since been lost and the figure is indeterminate, so its real identity for the present must remain problematical. Very possibly it represents an undescribed form.

PLIOCENE

Owing to the comparative scarcity of chiton remains in the deposits of Pliocene age, they have been discovered at but few localities, all southern and central California. In the literature the classification of the several formations in this part of our area is rather confusing, so that which I have adopted is in part tentative.

Purisima Formation:

3. Purisima, San Mateo County, California. *"Cryptochiton* c. f. *stelleri"* is reported from the "Neocene" at Purisima by Ashley ('95, p. 327). As his work was done before the local geological nomenclature was far developed, the exact vertical position of his specimens is probably uncertain.

San Diego Formation:

4. Sea cliff at Pacific Beach, San Diego County, California (Mrs. Kate Stephens).

Fossils from this exposure have been listed and their relationships discussed by Arnold (:03, p. 57-58, 60-64; :06, p. 28), who, however, records no chitons. The following are now listed:

Cryptochiton stelleri (Middendorff)
Ischnochiton conspicuus Carpenter

Regarding one of these, Mrs. Stephens writes, "I got it from the Pliocene beds, but I believe that Pleistocene beds are found there, too, so it may have fallen down from that. I can't be sure." It is apparent that there is here an uncertainty, probably applicable to all the specimens seen from this exposure, which can only be removed by further work in the field.

5. Rustic Canyon, Santa Monica, California (F. C. Clark).

Mopalia sp.

This locality is quoted as Pliocene on the authority of Dr. F. C. Clark. I have not visited it, nor seen the association of

species, and am therefore uncertain to which formation the horizon belongs. The small *Mopalia,* a single valve of which is the only chiton discovered, seems, however, to be inseparable specifically from those occurring so commonly in the Pleistocene of the same vicinity.

6. Excavation on Fourth Street, between Hill Street and Broadway, Los Angeles, California (Moody).

Moody (:16, p. 42) has recorded an undetermined chiton from this exposure. In the same paper he described the associated fauna and its relationships in some detail.[2]

Santa Barbara Formation:

7. Deadman Island, San Pedro, California (Chace).

This deposit has been described very fully by Arnold (:03, p. 14-17). He records one chiton:

Cryptochiton stelleri (Middendorff)

To this is here added:

Katharina tunicata (Wood)

PLEISTOCENE

The chiton fauna of the Pleistocene deposits studied, again all southern Californian, shows near relation to the living fauna not only by essential identity of species, but by the comparatively great development of this portion of the fauna when considered with relation to the weak position it occupies in the Pliocene. In the San Pedro Formation, which is the only one from which we have any chitons, they divide as readily as the remaining molluscan fauna into the two primary series established by Arnold.

Lower San Pedro Series:

8. Deadman Island, San Pedro, California (Arnold).

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[2] Since this paper was written, the recovery of two of Moody's specimens enables them to be recorded as follows:

1. *Callistochiton crassicostatus* Pilsbry. The single specimen seen is a well preserved head valve of somewhat peculiar aspect, and it is possible that this determination will have to be revised later on.

2. *Callistochiton palmulatus* Carpenter. The single specimen is a well preserved tail valve measuring, long. 4.3, diam. 5.2, alt. 4.8 mm. It seems much nearer typical *palmulatus* than most of the other fossil specimens seen, although a few of those from Long Wharf Canyon, Santa Monica, are somewhat similar.

This exposure has received very full treatment at the hands of Arnold (:03, p. 18-21, 35-47). The single chiton recorded is:

Cryptochiton stelleri (Middendorff)

I have seen no chiton material definitely known to be from this horizon, but it is possible that a portion of the miscellaneous material in the Arnold and Oldroyd collections came originally from these beds.

9. "The Chiton Bed," near the pavilion, Point Fermin, Los Angeles County, California (E. P. Chace, E. M. Chace and S. S. Berry). (Plate XVI).

This interesting exposure is the one which has been recently described by Mr. and Mrs. Chace (:19, p. 41-43). So unusual is the deposit from the large number of chiton valves contained in it that they have termed it "The Chiton Bed," a usage so convenient as a brief means of distinguishing it from neighboring deposits of the same formation that I retain it in the following pages. Besides giving a considerable faunal list, their paper described the field relations of the exposure as follows:

> It is situated a few yards west of the western boundary of the picnic grounds around Peck's Pavilion, and hardly more than ten feet below the upper edge of the bluff. Directly below the rather sandy topsoil a thin layer of red-brown sandstone is exposed, then comes the fossil-bearing stratum: a gray sand, in some places so hard as to offer considerable resistance to the caseknife, in others weathered to a loose, trickly deposit. Immediately below this is another layer of the red-brown previously seen. Owing to the conformation of the bluff I am unable to say what lies beneath the second red layer. There are numerous small stones in the fossiliferous layer, some of them apparently chalcedony, others our common white quartz, still others are fragments of a dark shale. These stones have probably prevented a previous report of this exposure, as at a little distance the shells are thoroughly masked by these bits of rock. It is an odd fact that although the gray sandstone layer continues, apparently unchanged, both to the east and west of the ten-foot section in which we have worked, we were unable to find any shells except in that small space."

Later in their paper these authors express some doubt as to the geologic age of these strata, but it seems to me that the evidence of the lithology, of the fauna in general, and especially of the chitons themselves, is conclusive that they should be correlated with the Lower San Pedro. The latter in its characteristic form is likewise a rather hard gray sandstone, and the aspect of the embedded fauna, as here, is quite distinctly northern. As will be noticed from the following list, the

chitons are for the most part species still to be found living in this vicinity, but several of these are decidedly rare at so low a latitude, and the entire facies of the association, as will be brought out more fully a little later, is strikingly that of the shores of Monterey and San Luis Obispo counties at the present day.

Tonicella lineata (Wood)
Cyanoplax hartwegii (Carpenter)
" *fackenthallæ* Berry
Nuttallina californica (Nuttall)
Mopalia muscosa (Gould)
" *lignosa* (Gould)
" *ciliata* (Sowerby)
Placiphorella velata Carpenter
Cryptochiton stelleri Middendorff
Chætopleura gemma Carpenter
Ischnochiton magdalenensis (Hinds)
" *cooperi* Carpenter
Callistochiton decoratus punctocostatus Pilsbry
" " *ferminicus* Berry, new subspecies
" *crassicostatus* Pilsbry

By all odds the most abundant chiton in the bed is *Nuttallina californica,* to which species are referable over two-fifths of the 350 specimens obtained. *Ischnochiton magdalenensis* accounts for another fifth, and *Mopalia muscosa* for nearly a seventh of the total, a proportion probably not very different from that one would encounter in tide-pool collecting in the Monterey region at the present time. Of the remaining species, *Callistochiton crassicostatus, Cyanoplax hartwegii, Tonicella lineata,* and *Mopalia ciliata,* rank in abundance in the order named. The others are scattering.

10. Near the lighthouse, Point Fermin, Los Angeles County, California (E. P. and E. M. Chace).

This appears to be an exposure from which no faunal reports have been published. Like the preceding, it appears to be Lower San Pedro, and perhaps represents part of the same general deposit, but the chitons are relatively fewer and *Nuttallina,* the most abundant form at the Chiton Bed, is lacking from the list.

Tonicella lineata (Wood)
Mopalia lignosa (Gould)
" *ciliata* (Sowerby)
Placiphorella velata Carpenter
Ischnochiton magdalenensis (Hinds)
" *cooperi* Carpenter

Of the 39 specimens taken, about three-fifths are *Ischnochiton magdalenensis,* an eighth are *Mopalia ciliata,* an eighth are *Ischnochiton cooperi,* and a tenth are *Tonicella lineata.*

11. Nob Hill Cut, San Pedro, California (Oldroyd).

I have not been successful in finding a published account of this very interesting exposure, although to judge from the chitons (I have seen no other representatives) it must possess a somewhat remarkable fauna. The chitons attain a considerable development here and include the following species:

Lepidochitona dentiens (Gould)
Nuttallina californica (Nuttall)
Mopalia muscosa (Gould)
" *acuta* (Carpenter)
Cryptochiton stelleri (Middendorff)
Ischnochiton fallax Carpenter
" *cooperi* Carpenter
Callistochiton crassicostatus Pilsbry
" *palmulatus mirabilis* Pilsbry

Over half of the 117 specimens obtained here by Mr. Oldroyd are *Lepidochitona dentiens,* nearly one-fifth are *Mopalia acuta,* and about one-eighth are *Callistochiton crassicostatus.*

12. "Crawfish George's", near Yacht Club, San Pedro, California (Arnold, Chace).

This exposure has been very comprehensively treated by Arnold (:03, p. 24-27, 35-47). He records no chitons. Mr. Chace's material, however, includes the following three:

Mopalia muscosa (Gould)
" sp.
Ischnochiton cooperi Carpenter

The fauna as listed by Arnold includes a remarkable number of northern types, mingled as well with some of the more

southern. In many respects the association appears more or less transitional between the Lower San Pedro Series and the Upper, so perhaps is an older deposition than the typical Upper San Pedro. It is the only supposedly Upper San Pedro horizon in which *Ischnochiton cooperi* has been found. Possibly there has been a confusion of horizons, and both Upper and Lower are really present here. I have accordingly treated it as Lower San Pedro in my table. Further chiton material from this locality is badly needed and might throw valuable light on the relationships involved. Ashley's record of *Ischnochiton regularis* ('95, p. 343), from a supposedly Pliocene exposure which Arnold (:03, p. 24) identifies with the present one, also requires confirmation.

Upper San Pedro Series:

13. Lumber yard, San Pedro, California (Arnold).

This is the type locality of the Upper San Pedro Series as described by Arnold. He records an extensive fauna (:03, p. 27-29, 35-47), but only two chitons are included:

Mopalia ciliata (Sowerby) [=*muscosa* (Gould) of the present paper]
Ischnochiton regularis (Carpenter)

I have had no material known with certainty to be from this horizon. The specimens upon which Arnold based the determinations cited appear to have been lost and attempts to trace them have met with no success.

14. Signal (or Los Cerritos) Hill, Long Beach, California (Oldroyd).

Accounts of the stratigraphic relations and fauna of the Pleistocene of Los Cerritos Hill have been published by Arnold (:03, p. 30-32, 35-47), who lists no chitons, and by Oldroyd (:14, p. 81), who records one,

Ischnochiton conspicuus Carpenter

The further material afforded by the Oldroyd collection contains in addition to this species three others,

Mopalia acuta (Carpenter)
Ischnochiton sp.
Callistochiton palmulatus mirabilis Pilsbry

15. Long Wharf Canyon, Santa Monica, California (F. C. Clark).

This extremely rich deposit has never been thoroughly dealt with in the literature, although a number of species, including many novelties, have at various times been described from it. Chace (:17, p. 30-31) has listed several of the chitons. From the faunal evidence the stratigraphic affiliations are unqualifiedly with the Upper San Pedro. The majority of the species are essentially identical with those inhabiting the waters of the adjacent coast at the present day, but they are also usually species whose present metropolis lies to the south rather than to the north, or even in some instances, as *Ischnochiton acrior* of our list, no longer occur north of Lower California. The following chitons have been recognized from the material submitted by Dr. Clark:

Leptochiton clarki Berry, new species
Mopalia acuta (Carpenter)
" sp.
Acanthochitona avicula (Carpenter)
Ischnochiton conspicuus Carpenter
" *acrior* Carpenter
" *pectinulatus* Carpenter
" *sanctæmonicæ* Berry, new species
Callistochiton crassicostatus Pilsbry
" *palmulatus mirabilis* Pilsbry

The most remarkable faunal feature here is the enormous relative abundance of the two species of *Callistochiton*. Out of 330 valves, 197, or nearly two-thirds, are *C. p. mirabilis*, and 71, or nearly one-fifth, are *C. crassicostatus*. The unidentified *Mopalia* with 18, *Ischnochiton acrior* with 14, and *I. sanctæmonicæ* with 13, are the only others met with in any number.

16. "Coal mine", west side of Point Loma, San Diego County, California (Mr. and Mrs. Frank Stephens, Carl L. Hubbs).

This horizon, always referred to by Mrs. Stephens as "the coal mine", offers a fauna which is in some respects quite unique, yet seems to have had very little attention from pre-

vious workers.[3] It is situated in the sea cliff about half way of the peninsula on the western or ocean side. After revisiting the locality at my request, Mr. Stephens writes under date of June 5, 1918: "The bed containing the fossil shells lies unconformably on the strata containing the lignite, and is of much later age. Only fragments of the fossil bed are left as the sea is wearing the cliff away." He failed to find any further chitons, but the following had been secured previously:

Mopalia muscosa (Gould)
Cryptochiton stelleri (Middendorff)
Ischnochiton conspicuus Carpenter
" *acrior* Carpenter
Callistochiton crassicostatus Pilsbry

Cryptochiton stelleri and *Acmæa mitra* seem to be adventitious northern elements, the presence of which is not at first glance easy to understand, as the aspect of the remaining fauna is decidedly southern. For the latter reason I correlate the exposure with the Upper San Pedro, although the faunal list finds no complete parallel in that of any of the previously described horizons.

17. Along the sea cliff between one and two miles north of Point Loma and Ocean Beach, San Diego County, California (Cal. Acad. Sci. Loc. 108).

"The fossils were obtained from coarse sand and gravel which occurs just above the contact between the cretaceous(?) and the overlying late formation. The fossils occur about 50 ft. from the water. The formation in which they occur is almost horizontal."

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[3] The full list of species identified other than the chitons listed above seems worthy of record, so is appended here.:

Acmæa scabra Gould (=*spectrum* Nuttall)
" *mitra* Eschscholtz
Fissurella volcano Reeve
Diadora aspera (Eschscholtz)
Haliotis cracherodii Leach
Tegula (Chlorostoma) funebralis (A. Adams)
Tegula (Chlorostoma) sp.
Norrissia norrissii (Sowerby)
Astræa undosa (Wood)
Crepidula aculeata Gmelin
" cf. *lessonii* Broderip and *explanata* Gould
Hipponix tumens Carpenter
" cf. *cranioides* Carpenter
Littorina scutulata Gould
" *planaxis* Philippi
Cerithidea sacrata Gould
Thais cf. *emarginata* (Deshayes)
Acanthina lugubris (Sowerby)
Alectrion cooperi (Forbes)
Gadinia reticulata Sowerby
Pecton (Plagioctenium) circularis Sowerby *(aequisulcatus* Carpenter)
Hinnites giganteus Gray
Septifer bifurcatus (Conrad)
Cardita subquadrata Carpenter
Chama exogyra Conrad
Phacoides californicus (Conrad)
Petricola carditoides Conrad
Cumingia lamellosa Sowerby
Saxicava sp.
Pholad sp.
Cancer productus Randall
Tetraclita rubescens Darwin

This locality is known to me only as above quoted. Quite possibly it is the same, or part of the same deposit as the "coal mine" referred to as No. 15 above. Two chitons were obtained,

Cryptochiton stelleri (Middendorff)
Ischnochiton acrior Carpenter

The appearance of the individual specimens is much like those from the preceding station. I refer them to the Upper San Pedro.

18. Spanish Bight, North Island, San Diego, California (Mrs. Kate Stephens).

This exposure has been given detailed treatment by Arnold (:03, p. 59-64), but without recording any chitons. Two species are represented in the material before me:

Ischnochiton conspicuus Carpenter
" *pectinulatus* Carpenter

STATIONS OF UNCERTAIN RELATIONSHIP

In the Oldroyd collection with the scant label "Upper San Pedro" are the following chitons, all from Southern California, and presumably from the neighborhood of San Pedro, but the exposure and exact locality unknown:

Mopalia muscosa (Gould)
" *lignosa* (Gould)
" *acuta* (Carpenter)
" sp.
Ischnochiton conspicuus Carpenter
" *fallax* Carpenter
" *cooperi* Carpenter
" cf. *sinudentatus* Carpenter
" sp.
Callistochiton crassicostatus Pilsbry

If, as seems probable, all of the above are from the same exposure, the association would seem to be much more that of the Lower than of the Upper San Pedro, as labeled.

In the Arnold collection labeled Deadman Island, California, (formation unknown) are the following:

Mopalia lignosa (Gould)
" *acuta* (Carpenter)
? *Lepidochitona denticns* (Gould)
Nuttallina californica (Nuttall)

All of these are no doubt from the Pleistocene, but whether from the Lower or Upper Series it would serve no good purpose to hazard a guess.

The exact formation from which Cooper recorded *Cryptochiton stelleri* as of the Pleistocene of San Diego, and *Ischnochiton magdalenensis* from the Pleistocene at Santa Barbara are not known to me.

It is strange that no chitons have been reported from the rich Pleistocene deposit on the beach behind the bathhouse at Santa Barbara. I did not find any during my exploration of these beds in 1903, although they must occur there.

Relative Abundance of Species

Chiton valves do not seem to be very common in most horizons and are really abundant only in four of those examined,—the Upper San Pedro Beds of Long Wharf Canyon, the Lower San Pedro at Nob Hill Cut, and the two Point Fermin exposures, especially that known as the "Chiton Bed." Out of a total of 1040 valves which constitute the principal subject matter of this paper, over one-half are the result of our few trips to the "Chiton Bed", and the overhauling of Dr. Clark's material from Long Wharf Canyon.

The most abundant species as fossils are not by any means always those most commonly taken in present day collecting. No less than 203 of the fossil valves are *Callistochiton palmulatus mirabilis,* and another *Callistochiton* (*crassicostatus*) stands second in point of abundance with 131, largely the consequence in both instances of their plentiful occurrence at Long Wharf Canyon. The only other species of which 25 or more specimens have come to hand are *Nuttallina californica* (161), *Lepidochitona denticns* (63), *Mopalia muscosa* (80), *Ischnochiton magdalenensis* (92), *Mopalia acuta* (49), *Mopalia ciliata* (47), *Ischnochiton acrior* (31), and *Ischnochiton cooperi* (26).

It is of some interest in this connection to note that the most abundant living species in the region whence practically all the fossils came are probably *Lepidochitona dentiens, Cyanoplax hartwegii, Nuttallina fluxa, Ischnochiton conspicuus, Ischnochiton pectinulatus, Mopalia muscosa,* and *Leptochiton rugatus.*

FAUNAL RELATIONS

It is too early in the study and the available material still far too scanty to permit much indulgence in the pastime of generalizing with any great degree of safety, but a few points which can be brought out with some measure of clearness by a study of the accompanying table are perhaps worthy of brief summarization. We are better protected than otherwise in proceeding thus because the facts in evidence stand fairly in corroboration of the major conclusions to which students of the other animal groups have been impelled by working out parallel data.

A recapitulation of the table shows the total number of species and subspecies for each of the principal formations to be as follows:

	Specifically determinable	Total
Oligocene	1	1
Pliocene	2 (3?)	3 (4?)
Pleistocene	28	33
Lower San Pedro 19		
Upper San Pedro 11		
Uncertain 4		

PLIOCENE

Leaving out the unique and extinct Oligocene species as insufficient of itself to point conclusively one way or the other, we find that the only certainly Pliocene species are *Katharina tunicata* and *Cryptochiton stelleri,* both northern forms, as would be expected by analogy with the remainder of the Pliocene fauna. These two species, however, happen both to be of wide distribution, ranging from south-central California as far north as Bering Sea, so do not help greatly in determining just how much colder than now the southern Californian waters of that period probably were.

	RECENT										
		LIVING									
	Indian Middens	Bering Sea	Southern Alaska	Puget Sound Region	Northern California	Monterey Region	Southern California	Lower California	Panamaic	Bathymetric Range in Fathoms
1. *Leptoch*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
2. *Oligoch*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
3. *Tonicel*	.....	×	××	××	××	××	×	.....	.....	0–30
4. *Cyanop*	.....	.....	.....	.....	.....	××	××	××	.....	0
5. *Cyanop*	.....	.....	.....	.....	.....	×	.....	.....	.....	0
6. *Lepidoc*	.....	.....	.....	×	×	×	××	××	.....	0
7. *Nuttalli*	.....	.....	.....	×	.....	××	?	.....	.....	0
8. *Mopali*	××	.....	×	××	××	××	××	×	.....	0–30
9. *Mopali*	.....	.....	××	××	××	××	×	.....	.....	0–30
10. *Mopali*	.....	.....	.....	.....	.....	×	××	×	.....	0
11. *Mopali*	.....	.....	×	××	××	××	?	?	.....	0–30
12. *Mopali*	.....	×	××	××	××	××	×	×	.....	0–50
13. *Mopali*	.....	.....	?	?	?	.....	.....	.....	.....	0–30
..* *Mopali*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
..* *Mopali*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
14. *Placiph*	.....	.....	×	×	××	××	×	×	.....	0–50
15. *Kathari*	×	×	××	××	××	××	×	.....	.....	0–20
16. *Acanth*	.....	.....	.....	.....	.....	.....	×	.....	?	0
17. *Cryptoc*	×	××	××	××	××	××	×	.....	.....	0–20
18. *Chaetop*	.....	.....	.....	×	××	××	×	×	.....	0–15
19. *Ischnoc*	.....	.....	.....	.....	×	××	×	.....	.....	0–15
20. *Ischnoc*	.....	.....	.....	.....	××	××	××	×	.....	0
21. *Ischnoc*	××	.....	.....	.....	.....	?	××	××	?	0
22. *Ischnoc*	.....	.....	.....	.....	.....	.....	.....	××	?	0
23. *Ischnoc*	.....	.....	.....	.....	..×..	××	×	.....	.....	0
24. *Ischnoc*	.....	.....	.....	.....	.....	×	××	××	.....	0
25. *Ischnoc*	.....	.....	.....	.....	×	××	×	.....	.....	0
26. *Ischnoc*	.....	.....	××	××	××	××	×	×	.....	0–50
27. *Ischnoc*	.....	.....	.....	.....	.....	?	.....	.....	.....	0
28. *Ischnoc*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
29. *Ischnoc*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
30. *Callisto*	.....	.....	.....	.....	.....	×	××	×	.....	0–10
31. *Callisto*	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
32. *Callisto*	.....	.....	.....	.....	.....	××	××	×	.....	0–15
33. *Callisto*	.....	.....	.....	.....	.....	××	××	.....	.....	0–15

aper or on good authority elsewhere.
ace.

TABLE I. Distribution of West American Fossil Chitons.

	Oligocene	Miocene	Pliocene				Pleistocene										Uncertain Horizons (probably Pleistocene)	Recent	Living								
	Sooke Formation		Purisima Formation	San Diego Formation	Santa Barbara Formation		Lower San Pedro Series					Upper San Pedro Series						Indian Middens									
	Vancouver Island		Purisima	Pacific Beach	Santa Monica	Deadman Island	Deadman Island	Pt. Fermin (Chiton Bed)	Pt. Fermin (Lighthouse)	Nob Hill Cut	Crawfish George's	San Pedro Lumber Yard	Signal Hill	Santa Monica	Pt. Loma	Spanish Bight			Bering Sea	Southern Alaska	Puget Sound Region	Northern California	Monterey Region	Southern California	Lower California	Panamaic	Bathymetric Range in Fathoms
1. *Leptochiton clarki* Berry	×													×													
2. *Oligochiton lioplax* Berry								×	×										×	××	××	××	××	×			0–30
3. *Tonicella lineata* (Wood)								××															××	××	××		0
4. *Cyanoplax hartwegii* (Carpenter)								×															×				0
5. *Cyanoplax fackenthallae* Berry										××							?				×	×	×	××	××		0
6. *Lepidochitona dentiens* (Gould)								××		×							×				×		××	?			0
7. *Nuttallina californica* (Nuttall)								××		×	×	×			×		×			×	××	××	××	×			0–30
8. *Mopalia muscosa* (Gould)																	×			××	××	××	×	××	×		0–30
9. *Mopalia hindsii* (Sowerby)										××			×	×			×				××	××	?	?			0–30
10. *Mopalia acuta* (Carpenter)								×	×								×		×	××	××	××	?	×			0–50
11. *Mopalia lignosa* (Gould)								×	××								×			?	?	?					0–30
12. *Mopalia ciliata* (Sowerby)														××													
13. *Mopalia cf. sinuata* (Carpenter)					?																						
..* *Mopalia sp*											×						×			×	×	××	××	×	×		0–50
..* *Mopalia sp*								×	×								×		×	××	××	××	××	×		?	0–20
14. *Placiphorella velata* Carpenter														×										×			0
15. *Katharina tunicata* (Wood)					×												×		×	××	××	××	××	×			0–20
16. *Acanthochitona avicula* (Carpenter)														×										×			0
17. *Cryptochiton stelleri* (Middendorff)			×	×	×	×	×	×		×					×		×		×	××	××	××	××	×			0–20
18. *Chaetopleura gemma* Carpenter								×														×	××	×			0–15
19. *Ischnochiton fallax* Carpenter										×							×					×	××	×			0–15
20. *Ischnochiton magdalensis* (Hinds)								××	××								×					××	××	××			0
21. *Ischnochiton conspicuus* Carpenter				?									×	×	×	×	×		××				?	××	××	?	0
22. *Ischnochiton acrior* Carpenter														××	××		×								××	?	0
23. *Ischnochiton regularis* (Carpenter)											?	?											××	×			0
24. *Ischnochiton pectinulatus* Carpenter														?		×							×	××	××		0
25. *Ischnochiton cooperi* Carpenter								×	××	×	×						×					×	××	×			0
26. *Ischnochiton mertensii* (Middendorff)																	×			××	××	××	××	×	×		0–10
27. *Ischnochiton cf. sinudentatus* Carpenter																	×						?				0
28. *Ischnochiton sanctaemonicae* Berry														××													
29. *Ischnochiton sp*													×														
30. *Callistochiton decoratus punctocostatus* Pilsbry								×									×						×	××	×		0–10
31. *Callistochiton decoratus ferminicus* Berry								×																			
32. *Callistochiton crassicostatus* Pilsbry								×		××				××	×		×						××	××	×		0–15
33. *Callistochiton palmulatus mirabilis* Pilsbry										×			×	××			×						××	××			0–15

*not separately numbered as may possibly prove conspecific with one or another of the other species listed.

×designates occurrence recorded in this paper or on good authority elsewhere.
××designates a degree of relative abundance.

Pleistocene

Lower San Pedro Series:

The Pleistocene chiton faunas are sufficiently extensive to enable finer conclusions to be drawn. Recorded from the Lower San Pedro are 19 species and subspecies. All are forms which we know are accustomed to live between tides or in comparatively shallow water. Compared with the recent fauna these show the following interesting relationships:

Relations of Lower San Pedro Chiton Fauna with Living Fauna of Corresponding Latitude

	Number of species	Per cent. of total
Extinct or unknown living	1	5.3
Now living commonly in same region	8	42.1
Now living in same region but more or less rare	4	21.1
Now living on other parts of the coast, but not known to occur in same latitude as fossils	6	31.6
Now living more commonly to north than south	6	31.6
Now living more commonly to south than north	0	0
Known to occur only on shores to north	6	31.6
Known to occur only on shores to south	0	0

It is evident from this that the Lower San Pedro chitons abundantly support Arnold's conclusions[4] that as compared with the present, *relatively* "boreal conditions still preponderated during this period." They show just as conclusively, however, that these conditions were "cold" only in a relative way, and by no means *actually* boreal as this term is generally understood by the zoo-geographer. To one familiar with the recent chitons this whole Lower San Pedro association is strikingly reminiscent of that which now occurs on the shores of central California, notably Monterey Bay and the coasts of Monterey and San Luis Obispo counties just to the southward. Not only are all the species, save one *Callistochiton,* still to be found living in that region, but those most abundant and characteristic in the Lower San Pedro are similarly abundant and characteristic in the Monterey County fauna today. Among the fossils it is quite true that when an attempt is made to apply the reverse of this dictum a few conspicuous absences are found, but these are very conceivably due to the incompleteness of the record and may well be filled in later. In any event, nowhere else in the recent fauna can be found such a peculiar assemblage of species in association as *Tonicella lineata, Cyanoplax hart-*

[4] :03, p. 66.

wegii (not known to occur north of Monterey), *Nuttallina californica, Mopalia lignosa* (not positively recorded south of San Luis Obispo County), *M. acuta* (unrecorded north of Monterey), *M. ciliata, Placiphorella velata, Cryptochiton stelleri, Chaetopleura gemma, Ischnochiton fallax, I. magdalenensis, I. cooperi, Callistochiton decoratus punctocostatus* (this one barely recorded from as far north as Monterey), *C. palmulatus mirabilis,*—as far as it goes it is like calling the roll on a Pacific Grove beach! This is again brought out rather better by means of a table. *Callistochiton decoratus ferminicus,* because unknown in the recent fauna, is left out of account.

Relations of Lower San Pedro Chiton Fauna with Living Fauna of Monterey Region

	Number of species	Per cent. of total
Common and characteristic at Monterey or not known to occur elsewhere	15	83.3
More common to north or south but recorded from Monterey	3	16.7
Living rarely to north of Monterey region	4	22.2
Living rarely to south of Monterey region	2	11.1
Not known to occur north of Monterey region	5	27.8
Not known to occur south of Monterey region	7	38.9
Not known to occur in region of Monterey	0	0

Summing up it may be said that the chiton remains offer decided evidence that while the oceanic temperatures of southern California were very distinctly cooler during the Lower Pleistocene period than at the present time, the difference was nevertheless very little, if any, greater than that now prevailing between the waters of Monterey and Los Angeles counties, and, if the chitons are a true criterion, was quite probably about the same.

Upper San Pedro Series:

The total number of species here listed from the Upper San Pedro is 11. These may be given tabular treatment as follows:

Relations of Upper San Pedro Chiton Fauna with Living Fauna of Corresponding Latitude

	Number of species	Per cent. of total
Extinct or unknown living	2	18.2
Now living commonly in same region	5	45.5
Now living in same region but infrequent	2	18.2
Now living on other parts of coast, but not known to occur in same latitude as fossils	2	18.2
Now living more commonly to north than south	2	18.2
Now living more commonly to south than north	2	18.2
Known to occur only to north	1	9.1
Known to occur only to south	1	9.1

The evidence here is not altogether clear cut, but is easily indicative of higher oceanic temperatures than prevailed during the preceding period. This is better brought out when the fauna of a single horizon is taken by itself, the conflicting evidence being largely due to the peculiarities found in the faunas of such exposures as those at Point Loma. Taken as a whole, however, agreement is good with Arnold's statement (:03, p. 66) that "the fauna of the upper San Pedro series is southern in character, and, as would be expected, approaches more nearly the present living fauna of the San Pedro region." The chitons do not, however, well support his further conclusion that deposition during this period occurred in shallower water than during Lower San Pedro times. The chitons of the Lower San Pedro exposures on Point Fermin, as we have already seen, are practically exclusively shore species, a few only of which have been found extending to a few fathoms depth. Those of Long Wharf Canyon, which is unqualifiedly an Upper San Pedro horizon, even though mainly shore forms, include a few species like *Leptochiton clarki* and *Ischnochiton sanctæmonicæ* which have the aspect of off-shore types from at least moderate depths. No doubt different horizons within each period will show considerable modifications in this respect. As an association the Upper San Pedro chitons are not easy to bring into correlation with those of any restricted region of the coast at the present time. By itself, the Long Wharf Canyon fauna is rather strongly reminiscent of that of the west coast of Lower California in the neighborhood of the 28th parallel. This impression is probably due very largely, if not wholly, so far as the chitons are concerned, to the presence as a strong element in the fauna of the now characteristically Lower Californian *Ischnochiton acrior*. At the same time we find at the "coal mine" locality on Point Loma, this same southern species occurring simultaneously with the strongly northern *Cryptochiton stelleri*, an association which for the present we can only regard as anomalous. Dr. Clark has so far failed to find the slightest trace of *Cryptochiton* in all his quarrying and sifting at Santa Monica.

FORMATIONAL INTER-RELATIONSHIPS OF CHITON FAUNA

	Oligocene	Pliocene	Lower San Pedro	Upper San Pedro	Recent
Oligocene	1				
Pliocene	0	3			
Pleistocene:					
Lower San Pedro	0	1	19		
Upper San Pedro	0	2	5	11	
Recent	0	3	18	9	110+

A conspicuous fact brought out in several of the tables is the small number of species appearing in all formations which are extinct or not yet known to occur living. The single Oligocene species is unique and, as would be anticipated, is probably extinct. But with one exception all the Pliocene and Lower Pleistocene forms which have been specifically determined are also of recent occurrence. This is likewise true of most of the fauna from the Upper (San Pedro) Pleistocene, but two species here described as new from the rocks of this period have not yet been discovered in the recent state.

The species peculiar to each formation are:

	Number of species	Per cent. of total
Oligocene	1	100
Pliocene	1*	33
Pleistocene:		
Lower San Pedro	13**	68.4
Upper San Pedro	5***	45.5

*all occur also in living fauna.
**all but one also known to occur in living fauna.
***all but two also known to occur in living fauna.

No doubt these figures will be very greatly modified by the results of later investigation, but to some degree are probably dependable. An analysis in detail would probably show the more characteristic species of the respective formations to be somewhat as follows, all but *Mopalia acuta* being, so far as is known, confined to the formation under which they are listed:

Oligocene: *Oligochiton lioplax*

Pliocene: *Katharina tunicata*

Pleistocene—

Lower San Pedro *Tonicella lineata*
Cyanoplax hartwegii
" *fackenthallæ*
Nuttallina californica
Mopalia lignosa
" *ciliata*

	Placiphorella velata
	Ischnochiton fallax
	Ischnochiton magdalenensis
	" *cooperi*
Upper San Pedro	*Mopalia acuta*
	Ischnochiton acrior
	" *pectinulatus*
	" *sanctæmonicæ*

Here, too, later work will no doubt bring about appreciable modification. One feels inclined to prophesy that *Katharina tunicata* will be found to occur in the Lower San Pedro as well as in the Pliocene, while it also seems reasonable that a large proportion of the species just now apparently characteristic of the Lower Pleistocene will eventually be discovered in the Pliocene as well. In addition to the forms specifically characteristic as noted, the Upper San Pedro horizons seem generally to be marked by an extraordinarily abundant development of *Callistochiton* as compared with individuals of other genera.

Parts of Animal Preserved as Fossils

In chitons, as probably in every division of animals, all normal structures possess some special element to contribute toward a properly phylogenetic classification of the group. In such a classification it is no more proper to neglect a certain organ or group of organs than it is to leave out of consideration some difficult species or genus. Probably no one would dispute this, theoretically at least, but as a matter of actual practice, and with no more data to work with than we have at present, it is quite impossible, as in almost all other groups, even reasonably to approach so ambitious an ideal. For the time being, we must perforce be content with putting our reliance upon those structures which by reason of hardness, like the shell, or of adaptability to mounting, like the radula and girdle scales, are readily susceptible of preservation.

In the case of fossils the very nature of things limits us to consideration of the shell, or, rather, to the shelly plates, eight in number, into which the chiton shell is divided. In life these are regularly meristic in position and are held together by the stout chitinous or leathery girdle, itself variously beset, both

above and below, with scales, spines, setæ, or other horny or calcareous appendages. When some of our fossiliferous rocks have had their due of microscopic investigation, no doubt chiton girdle scales will be found, perhaps sometimes even in abundance. But up to the present there has been no recovery of any remains beyond the valves of the shell. All other structures, being of but problematic value to the paleontologist, will be dealt with only incidentally in this paper. Except where for special reasons it becomes hardly avoidable, discussion of all such will be left for papers dealing primarily with the recent chitons, to which the student who wishes to push the matter further may readily refer.

The paleontologist, *as such*, has to content himself with an odd valve pried here and there from the rocks, rarely with any evident remaining connection with any of the other valves originally its fellows, so the systematic discussion in a work of this scope necessarily must take purview of the situation and concern itself chiefly with the description and identification of such fragmental remains.

The Shell of Chitons

The valves of the chiton shell are not alike, nor are any two of them absolutely so, though the more central ones are very similar. To the casual observer they fall easily into three principal categories: the anteriormost, or *"head" valve*, as it is commonly called, the six intermediate or *median valves*, and the posteriormost or *"tail" valve*. Perhaps these terms are not strictly scientific either in etymology or application, but they are the ones generally in use and the most convenient we have. Each valve in articulating with its neighbors juts under the one just in front and over the one just behind. Consequently the head valve differs from all the others in being not only more or less evenly crescentic, due to its terminal position, but without accessory plates in front other than the marginal *insertion plate* present in nearly all chitons except a part of the family *Lepidopleuridæ*. All the other valves have a pair of sharp, plate-like apophyses projecting on either side in front, the *sutural laminæ*. The tail valve is, however, not straight or angular behind, as are usually the intermediate valves, but is evenly crescentic or specially shaped in some other way. Its oldest or umbonal

portion, technically known as the *mucro*, is usually evident as a submedian, conical projection of greater or less prominence, and is a characteristic feature.

The shelly substance in all the valves is characteristically formed of two layers,—an inner, usually hard, semi-porcellanous tissue known as the *articulamentum*, and an outer, usually softer, very different appearing, surface layer, the *tegmentum*. The articulamentum generally projects past the tegmentum on the sides and in front to form the mechanism of articulation, namely the sutural laminæ already described, and the toothed or simple *insertion plates* which serve for the attachment of the girdle at the sides of the median valves and around the ends, anterior or posterior as the case may be, of the terminal valves. The insertion plates are usually divided by one or more *slits* into more or less evident *teeth*. Sometimes evident in the articulamentum are thread-like lines, or lines of pores, running radially from the valve umbo and leading one into each slit, thus marking the position of the slit through the previous stages of growth. The sutural laminæ are separated in the central line by a sort of bay leading back nearly or quite to the margin of the tegmentum, the *sutural* or *jugal sinus*.

Those portions of the tegmentum just over where the insertion plates push from under are referred to as the *caves*, and the tissue of the little cliffs so formed as *cave tissue*. This tissue sometimes evinces special structural features of value.

Dorsally, the tegmentum is typically capable of delimitation into several distinct areas, which, in spite of modifications in a considerable number of species, yet maintain themselves through the group with a somewhat remarkable constancy. In the median valves the regions of the tegmentum lying back of the radial articulamental lines above mentioned, and thus overlying and coinciding with the old insertion plate tissue, are generally a little elevated, or may be bounded by a ridge or line of sculpturing in front. Their sculpture is subject to elaboration on a different plan from that of the rest of the valve and is primarily radial, rather than longitudinal as elsewhere. They are apt to be very definite in their boundaries and are known as the *lateral areas*. The area lying in front of them is called the *central area*. The region adjacent to the *ridge* or *jugum* of the valve, except, of course, in the head valve, is known as the *jugal tract* and the more lateral portions occupying the

side slopes as the *pleural tracts.* In *Acanthochitona* and some other forms, the boundary between the jugal and pleural tracts is better marked than that of the lateral areas, and the entire region of the slopes is called the *latero-pleural areas.* The tegmentum of the median valves sometimes shows an angular projection in the median line behind, the *beak,* and more rarely a similar forward projection between the sutural laminæ in front. This, when present, is known as the *false beak.*

The tegmentum of the head valve is not so divisible into areas. Its sculpture is almost uniformly developed on the same general plan as that of the lateral areas, and, as with them, is primarily radial. The articulamentum of this valve is of course entirely made up of insertion plate tissue. The tail valve, on the other hand, has sutural laminæ similar to those of the median valves and its tegmentum is typically divided into two regions, a *central area* in front of the mucro, and a *posterior area* behind it. The central area coincides in significance and essential plan of sculpture with the central areas of the median valves. The posterior area is homologous with the lateral areas and is usually similar to them in sculpture, though it develops peculiarities of its own now and then. It is sometimes convenient to refer to the tegmental surface of the head valve and the posterior area of the tail valve together as the *terminal areas,* as they are frequently so similar in sculpture. The articulamentum, and sometimes the tegmentum also, of the tail valve is sometimes emarginated in the median line behind to form a *posterior sinus.*

SYSTEMATIC ACCOUNT

General Remarks

The general purport of the systematic portion of this paper is to give a catalogue of the known species of fossil chitons of western North America, systematically arranged, and in connection with each species to present

1. A brief summary of the synonymy, with those references to the literature as seem of special importance to the paleontologist, especially such as are accompanied by useful figures;

2. A short diagnosis of the more important differential characters based upon the shell alone, and rendered as concise as possible consonant with a reasonably certain identification of the species;

3. In the case of hitherto undescribed species, a full description;

4. A statement of the known geologic and geographic range;

5. A list of the specimens examined, with pertinent data;

6. Figures of the shell, including both exterior (dorsal) and interior (ventral) views of a head, a median, and a tail valve, wherever the condition of the specimens available makes this possible;

7. Special remarks.

No figures of any of the fossil species have been prepared from recent specimens, and the diagnoses likewise are drawn as exclusively from fossil specimens as the material has permitted. In several instances both figures and diagnosis could have been decidedly improved and amplified by a more extended use of recent specimens, but it has seemed best for the present to avoid this wherever possible. Similarly it has been thought best to mention only shell characters in the diagnoses, not because of any desire to place an exclusive systematic value upon them, but because, as has been stated, they are the only ones preserved by the fossils.

New Taxonomic Terms Proposed

The following taxonomic terms are published for the first time in the present paper:

Oligochiton lioplax, new genus and species
Leptochiton clarki, new species
Ischnochiton (Lepidozona) sanctæmonicæ, new species
Callistochitoninæ, new subfamily
Callistochiton decoratus ferminicus, new subspecies

Key to Genera

The following key to the genera mentioned in this paper, it is hoped, will prove reasonably workable. It is in considerable degree artificial, but a purely phylogenetic key based upon the

shells alone, as must necessarily be done in this instance, seems impossible at this time.

1. Small species without insertion plates or slits at margin of articulamentum (Family Lepidopleuridæ) ..... Leptochiton
1′. Valves with slitted or toothed insertion plates..... 2
2. Valves in adult composed of articulamentum only, in the living animal entirely covered by the girdle ..... Cryptochiton
2′. Valves showing both tegmentum and articulamentum.. 3
3. Valves with tegmental area greatly restricted, due to encroachment by girdle..... 4
3′. Valves with tegmental area not greatly restricted and girdle not greatly encroaching..... 5
4. Valves massive; tegmentum without striking sculpture ..... Katharina
4′. Valves comparatively delicate; tegmentum sculptured with a more or less scaly pattern..... Acanthochitona
5. Eave tissue spongy..... 6
5′. Eave tissue solid (Family Ischnochitonidæ)..... 12
6. Lateral areas always poorly differentiated..... 7
6′. Lateral areas generally distinct, often bounded in front by a diagonal rib; tail valve with a single pair of slits and a posterior sinus (Family Mopaliidæ, in greater part) 11
7. Valves normally proportioned; sculpture obsolete or of relatively simple type (Family Callochitonidæ).... 8
7′. Valves narrow, of more or less bizarre form; sculpture of tegmentum strongly granular..... Nuttallina
8. Surface of tegmentum smooth..... 9
8′. Surface of tegmentum finely granulose..... 10
9. Sutural laminæ and teeth very short and weakly developed; more than one slit on each side in median valves ..... Oligochiton
9′. Sutural laminæ and teeth well developed; median valves with a single slit on each side..... Tonicella
10. Valves stout; teeth oblique and more or less pointed in tail valve ..... Cyanoplax
10′. Valves delicate; teeth small and very numerous in end valves ..... Lepidochitona

11. Valves normally proportioned.....Mopalia
11′. Valves excessively short and wide.....Placiphorella
12. Valves with beaded sculpture; tegmentum strongly developed behind the articulamentum; median valves distinctly narrowed at sides; tail valve with short, stubby teeth and posterior mucro.....Chætopleura
12′. Lateral and terminal areas having heavy radial ribs; the insertion plates short and curving out into the slits, which correspond in position with the radial ribs..... ..... Callistochiton
12″. Valves normal, with variously developed sculpture and sharply cut, even teeth throughout.....Ischnochiton

Description of Species

Family **Lepidopleuridæ**
Genus **Leptochiton** Gray, 1847

1. **Leptochiton clarki** Berry, new species

(Plate I, fig. 10.)

Diagnosis: Valves small, delicate, without insertion plates; sculpture weak, consisting of rows of small granules, coalescing or overlapping to form weak longitudinal riblets on the central areas and radial ones on the lateral areas; sutural laminæ very low and wide, blending evenly into the shell margin.

Type: An intermediate valve, entered as Cat. No. 3987 of the writer's collection [S. S. B. 605].

Type Locality: Upper San Pedro Pleistocene of Long Wharf Canyon, Santa Monica, California; collector, Dr. F. C. Clark; 1 median valve.

Range: Unknown except type locality as given above.

Description: Intermediate valve small, high-arched, subangular on the ridge, the side slopes arcuate. Lateral areas

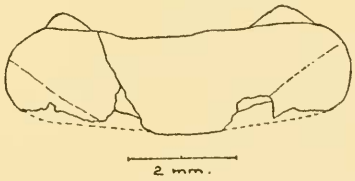

Fig. 1

Fig. 1. *Leptochiton clarki* Berry, new species. Dorsal aspect of type valve [605]; camera outline.

scarcely raised, sculptured all over by numerous, crowded, low, rounded granules, radially arranged and more or less coalescent to form low radial riblets (17-20 on a side ?), separated from each other by shallow, but quite distinctly cut, sulci. Central areas everywhere sculptured by numerous, more pointed, backwardly directed, more overlapping granules, which coalesce strongly to form about 55-60 low, granular, longitudinal riblets on each slope, their interspaces about half as wide as the riblets themselves and traversed by a rather weak, transverse threading which shows up more plainly where the tegmentum is slightly worn; riblets more or less oblique on the sides, bending inward as they approach the lateral areas, those nearer the center of the shell becoming straighter, and passing smoothly over the jugal region where they become a little narrower and more numerous than on the slopes.

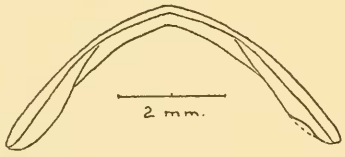

Fig. 2

Fig. 2. *Leptochiton clarki* Berry, new species. Anterior elevation of type valve [605]; camera outline.

Interior of valve with a rather strong, anterior, transverse callus. Insertion teeth obsolete. Slits none. Sutural laminæ very low, wide, evenly rounded in front, their outer slope only a little more abrupt than the inner and passing smoothly into the lateral margin of the shell.

Measurements: Caliper measurements of the type are,—long. 2.2, lat. 6.1, alt. 2.6 mm.

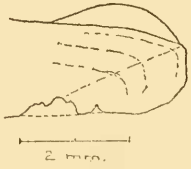

Fig. 3

Fig. 3. *Leptochiton clarki* Berry, new species. Dorsal aspect of right side of type valve [605]; camera outline.

Remarks: It is unfortunate that only a single valve has been discovered in all Dr. Clark's screenings of the only fossil Lepidopleurid we have seen. It is a modest little species, apparently

Fig. 4

Fig. 4. *Leptochiton clarki* Berry, new species. Ventral aspect of same; same scale as Fig. 3; camera outline.

allied to the prevailing group of species now living along the coast, although, chiefly because of the peculiar form of the sutural laminæ, I have been unable to identify it with any of them. From *L. nexus* (Carpenter), as represented by a specimen from off Laguna,[5] it differs in the much less sharply defined lateral areas and their much more distinct radial liration, as well as rather more numerous liræ of the central areas (55-60 instead of 50), which are not separated into distinct scales or granules.

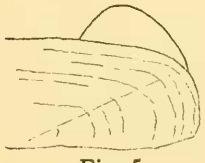

Fig. 5

Fig. 5. *Leptochiton heathi* Berry. Dorsal aspect of right side of valve v of paratype [124a] a recent specimen from 15 fathoms, off Monterey, California; same scale; camera outline.

Fig. 6

Fig. 6. *Leptochiton heathi* Berry. Ventral aspect of same; same scale; camera outline.

From valves of *L. heathi* Berry, that of the fossil specimen differs in being shorter and wider, in having a more angular

[5] c. f. Proc. Cal. Acad. Sci., (4), v. 9, p. 8.

dorsal ridge, in the more numerous liræ of the central areas (40-45 in *heathi*), in the more definite radial arrangement of the granules on the lateral areas, and in the conspicuously shorter and less pointed sutural laminæ.

From *L. rugatus* (Carpenter) it is separated by the weaker growth lines and consequently less conspicuous terracing of the lateral areas, together with the less crowded and more distinctly radial arrangement of the granules in this region, the more angular ridge, and the shape and position of the sutural laminæ.

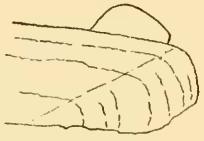

Fig. 7

Fig. 7. *Leptochiton rugatus* (Carpenter). Dorsal aspect of right side of valve iv of recent specimen from La Jolla, California, [111a]; same scale; camera outline.

Fig. 8

Fig. 8. *Leptochiton rugatus* (Carpenter). Ventral aspect of same; same scale; camera outline.

The fossil species differs from both *L. rugatus* and *L. heathi* in the very short and wide sutural laminæ, which in *L. rugatus*, moreover, are not marginal, but abruptly set over and separated by a sharp notch from the lateral margin of the shell. The differences in form of the sutural laminæ in these three species are very clearly brought out in the accompanying camera drawings (text figs. 3-8). *L. nexus* I have unfortunately not had opportunity to disarticulate.

The specific name is chosen in honor of Dr. F. C. Clark of Santa Monica, California.

Family **Callochitonidæ**

Subfamily Lepidochitoninæ

Genus **Oligochiton** Berry, new genus

Chiton with valves of normal form; insertion plates and teeth present, but very short. Surface of tegmentum smooth. Lateral areas scarcely defined. Sutural plates low and wide, separated by a wide and shallow sinus. Eaves spongy. Slits numerous in the end valves; probably 2 or 3 on a side in the median valves.

Type: the following species:

2. **Oligochiton lioplax** Berry, new species

(Plate I, figs. 1-6.)

Diagnosis: Valves of moderate size, without sculpture except lines of growth; lateral areas weakly delimited; mucro nearly median; slits numerous—13 in head valve, probably 2 or 3 on a side in median valves, about 15 in tail valve; teeth short; sutural laminæ short and broad, well separated.

Type: A tail valve [S. S. B. 608] in the collection of the department of geology, Leland Stanford Junior University.

Paratypes: A median valve [607] in the collection of the department of geology, Leland Stanford Junior University, and a head valve [606] in the writer's collection.

Type Locality: "N. P. 129", Sooke Formation Oligocene, "from conglomerates and sandstones found along the sea cliff between the mouths of Muir and Kirby creeks, west of Otter Point, southern Vancouver Island", British Columbia; 3 valves.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Original Number	Number in Author's Register	Remarks	Formation	Period
1	Ant.	Sea cliff, between mouths of Muir and Kirby creeks, Vancouver Id., B. C.....	H. Hannibal	Berry Coll. Cat. 5052	N. P. 129	[606]	Paratype	Sooke	Oligocene
1	Int.	Sea cliff, between mouths of Muir and Kirby creeks, Vancouver Id., B. C.....	H. Hannibal	Dept. Geology Stanford Univ.	N. P. 129	[607]	Paratype	Sooke	Oligocene
1	Post.	Sea cliff, between mouths of Muir and Kirby creeks, Vancouver Id., B. C....	H. Hannibal	Dept. Geology Stanford Univ.	N. P. 129	[608]	Type	Sooke	Oligocene
1	Post.	Sea cliff, between mouths of Muir and Kirby creeks, Vancouver Id., B. C....	Cal. Acd. Sci.	Cal. Acd. Sci.	C. A. S. 231	[939]		Sooke	Oligocene

Description: Head valve evenly crescentic, the slopes only slightly convex. Exterior somewhat worn and pitted; surface everywhere very finely and microscopically punctate, otherwise practically smooth, without any well developed pattern of sculpturing, except a few weak, concentric growth lines (marked in the specimen at hand by faint, narrow, alternating color bands of a darker tone than the body of the shell). Interior not examined, but the principal portion of the shell so delaminated as to reveal the presence of a number of strong radiating lines or grooves coincident with the marginal slits. Slits and grooves about 13 in number. Insertion teeth smooth, beveled somewhat at margin, but not very sharp.

Median valve not beaked, relatively short and wide, moderately high-arched; jugum with a strong but somewhat rounded angle, the specimen being somewhat abraded in this region; side slopes nearly straight. Tegmental surface unsculptured throughout except for a fine punctation and growth striæ like those of the head valve above described, the lines of growth and concentric color bands here rather more conspicuous; lateral areas flattened, only weakly elevated and therefore very indistinctly marked off from the pleural regions. Sutural laminæ short and broad, their margins arcuate, with the inner slopes more gradually tapering than the outer; well separated in the median line. Interior little calloused, the radial grooves on the sides 3-2; slits indistinct, but evidently 2-1, or 3-2, if the posterior groove on each side be assumed to have originally terminated in a slit.

Tail valve rather triangular in outline, the mucro nearly median; depressed, the side slopes flat and straight, posterior slope slightly concave; anterior margin strongly concave between the sutural laminæ; boundary between central and posterior areas clearly marked, forming an obtuse angle at the mucro and thence extending straight to the sharp antero-lateral angles of the tegmental margin. Sculpture exactly similar to that of the median and head valves. Sutural laminæ excessively short and broad, well separated. Interior with a strong, triangular, median callus bearing numerous lateral branches. Slits numerous but not everywhere definitely distinguishable in specimen examined; on the right side about 9 in number.[6] Insertion teeth smooth, very short.

[6] In the California Academy specimen the total number of radial lines can be counted from above and appears to be 15.

Eaves on all valves badly worn, but apparently rather spongy.

Measurements: Long. of head valve 6.+ mm., diameter 13+ mm.; long. of median valve 6.0 mm, diameter 20.0 mm.; long. of tail valve [608] 10.4, [939] 11. mm., diameter [608] 18.+, [939] 19.4+ mm.

Remarks: The specimens upon which the description of the present species is based, though none of them entire, have their various fragments for the most part in a fairly good state of preservation. The characters in which they are peculiar are not very striking, and it is therefore quite difficult at the present time to arrive at any precise determination of their relationships. The numerous slits, as well as the shorter teeth, preclude reference to *Tonicella*, and recall in some degree the description of the two species of *Spongioradsia (aleutica* and *multidentata)*, but the very spongy shell substance described for the latter group, and the fact that the teeth are even more poorly developed than in the fossil forms, militates against any attempt to join them. In other respects likewise, *Oligochiton* and *Spongioradsia* do not seem to have much in common. *Cyanoplax* and *Lepidochitona* have a differently formed tail valve, longer teeth, and a wider separation of the much better developed sutural laminæ. Nevertheless it is clear that the association of the Oligocene chiton should be more or less intimately with the genera named in the family *Callichitonidæ*. The comparatively weak development of the sutural laminæ and insertion plates perhaps indicates that *Oligochiton* is a primitive form, perhaps ancestral to some of the modern members of the family.

It is of particular interest as the oldest chiton thus far recorded from the West American formations.

Genus **Tonicella** Carpenter, 1873

3. **Tonicella lineata** (Wood, 1815)

(Plate II, figs. 1-5.)

1815. *Chiton lineatus* Wood, Gen. Conch., p. 15, pl. 2, f. 4-5.
1847. *Chiton lineatus* Middendorff, Mal. Ross., I, p. 109, pl. 12, f. 8-9.
1847. *Chiton lineatus* Sowerby, Conch. Ill., f. 77.
1847. *Chiton lineatus* Reeve, Conch. Icon., v. 4, Chiton, sp. 33, pl. 7, f. 33; detail pl., f. 33.

1857. *Chiton lineatus* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1856, pp. 208, 214, 223.
1857. *Tonicia lineata* Carpenter, op. cit., p. 317.
1864. *Chiton lineatus* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, pp. 523, 648, 684.
1864. *Tonicia lineata* Carpenter, op. cit., pp. 648, 684.
1879. *Tonicella lineata* Dall, Proc. U. S. Nat. Mus., v. 1, p. 296, 326, pl. 1, f. 5 (radula).
1892. *Tonicella lineata* Pilsbry, Man. Conch., (1), v. 14, p. 42, pl. 11, f. 25-28.
1919. *Tonicella lineata* Chace and Chace, Lorquinia, v. 2, p. 43 [3] (recorded from Pleistocene of Point Fermin, California).

Diagnosis: Valves low[7]; surface smooth, except for growth lines; lateral areas indistinct; traces of a color pattern of clean-cut wavy or zig-zag, oblique, longitudinal lines often persistent, becoming crescentic on the terminal valves; sutural laminæ short and wide, separated by a narrow sinus; tegmental margin often with an indication of false beaking in front; teeth short, but sharply cut, slightly projecting; eaves spongy; mucro high and very anterior in position; slits generally 8 to 10, 1-1, 8 to 10.

Recorded Range:

Pleistocene: Lower San Pedro Series—"Chiton Bed", Point Fermin, California (Chace and Chace, !); near lighthouse, Point Fermin, California (!).

Living: Plover Bay, Siberia, to Japan; Norton Sound, Bering Sea, to San Miguel Island, Santa Barbara County, California (!); between tides; juvenals to 30 fathoms.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4079.	[1183]	Lower San Pedro...	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4079.	[1041]	Lower San Pedro...	Pleistocene
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1366]	Lower San Pedro...	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1366]	Lower San Pedro...	Pleistocene
6	Int...	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Chace Coll..... Cal. Acd. Sci..... Berry Coll. Cat. 4079	[1400]	Lower San Pedro...	Pleistocene
3	Int..	Near lighthouse, Pt. Fermin, Cal.....	E. P. & E. M. Chace.....	Berry Coll. Cat. 4107.	[1096]	Lower San Pedro...	Pleistocene
1	Post.	Near lighthouse, Pt. Fermin, Cal.....	E. P. & E. M. Chace.....	Berry Coll. Cat. 4107.	[1097]	Lower San Pedro...	Pleistocene

[7] Varying to high in recent specimens from northern localities.

Remarks: Some of these specimens still retain well preserved traces of the original color pattern, as has already been remarked for other Lower San Pedro fossils by Arnold (:03, p. 20). The evidence thus afforded, as well as that of the flattish outline of the valves, indicates that this Lower Pleistocene race was closely similar to the more southern form of the species as now existing, for instance, along the coast of Monterey County, California, which has an aspect quite recognizably different from the Puget Sound and Alaskan shells.

Genus **Cyanoplax** (Pilsbry, 1892)

4. **Cyanoplax hartwegii** (Carpenter, 1855)

(Plate II, figs. 6-8.)

1855. *Chiton hartwegii* Carpenter, Proc. Zool. Soc. Lond., 1855, p. 231.
1855. *Chiton nuttalli* Carpenter, Proc. Zool. Soc. Lond., 1855, p. 231.
1864. *Trachydermon hartwegii* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, p. 649.
1864. *Trachydermon nuttallii* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, pp. 627, 649.
1879. *Chætopleura hartwegii* Dall, Proc. U. S. Nat. Mus., v. 1, pp. 296, 329, pl. 1, f. 10 (radula).
1879. *Chætopleura nuttallii* Dall, Proc. U. S. Nat. Mus., v. 1, p. 330.
1892. *Tonicella (Cyanoplax) hartwegii* & var. *nuttallii,* Pilsbry, Man. Conch., (1), v. 14, p. 45, 46, pl. 14, f. 81-85.
1894. *Trachydermon (Cyanoplax) hartwegii* Pilsbry, Nautilus, v. 8, p. 45.
1909. *Cyanoplax hartwegii* Thiele, Rev. Syst. Chit., I, p. 4, 7.
1909. *Trachydermon hartwegii* Thiele, id., p. 16.
1910. *Trachydermon hartwegii* Thiele, Rev. Syst., Chit., II, p. 107.
1919. *Cyanoplax hartwegii* Chace and Chace, Lorquinia, v. 2, p. 42 [2] (recorded from Pleistocene of Pt. Fermin, California).

Diagnosis: Valves low, relatively short and wide; sculpture, when not eroded, comprising a fine granulation overlain

by larger irregularly scattered warts, the lateral areas distinctly defined only in well preserved specimens; a color pattern of brownish flames or stains sometimes persistent; sutural laminæ short and wide, the sinus wide and shallow; tegmental border straight or only slightly sinuous in front; teeth short, not projecting; eaves spongy; mucro low, nearly median in position; slit formula 8 to 11, 1-1, 9 to 12, the slits and teeth of the tail valve very oblique.

Recorded Range:

Pleistocene: Lower San Pedro Series—"Chiton Bed", Point Fermin, California (Chace and Chace, !).

Living: Monterey, California, to Magdalena Bay, Lower California; between tides.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Berry Coll. Cat. 4039.	[943]	Lower San Pedro...	Pleistocene
3	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918.	Berry Coll. Cat. 4075.	[1030]	Lower San Pedro...	Pleistocene
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918.	Berry Coll. Cat. 4075.	[1079]	Lower San Pedro...	Pleistocene
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918.	Berry Coll. Cat. 4075.	[1081]	Lower San Pedro...	Pleistocene
2	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918.	Chace Coll.....	[1080]	Lower San Pedro...	Pleistocene
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1367]	Lower San Pedro...	Pleistocene
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1367]	Lower San Pedro...	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1367]	Lower San Pedro...	Pleistocene
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Cal. Acd. Sci.....	[1401]	Lower San Pedro...	Pleistocene
6	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Cal. Acd. Sci.....	[1402]	Lower San Pedro...	Pleistocene

Remarks: This species comes near to being the most abundant chiton now living on the coasts of California south of Monterey, with the possible exception of *Lepidochitona dentiens,* and from analogy with other species, one would naturally expect it to occur commonly in the Pleistocene. Such, however, is not the case. As a matter of fact, it has been unknown as a fossil until very recently, and seems to be very rare except at the Point Fermin "Chiton Bed", whence all my specimens were obtained. Most of these are too worn to show well the characteristic warty sculpture which in the shells of living animals can usually be relied on to separate *hartwegii* from all our other chitons.

5. Cyanoplax fackenthallæ Berry, 1919

(Plate II, figs. 9-10.)

1919. *Cyanoplax fackenthallæ* Berry, Lorquinia, v. 2, p. 45 [5].

Diagnosis:[8] Valves low, relatively short and wide, median ones distinctly beaked; sculpture comprising a fine, close, shagreen-like, quincuncial granulation over the entire surface, and a few rather irregular grooves on the terminal areas; lateral areas rather poorly defined; color pale, usually without markings; sutural laminæ triangular, projecting well forward, the sinus wide and deep; tegmental border sinuous in front; teeth of head and median valves very long and projecting, the slits extending only part way to base, in tail valve projected somewhat anteriorly, those on the sides of this valve oblique and distinctly pointed; eaves spongy; mucro low, somewhat posterior; slit formula 8, 2-2 (?), 11.

Recorded Range:

Pleistocene: Lower San Pedro Series — Chiton Bed, Point Fermin, California (!).

Living: Pacific Grove, California; between tides.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4103.	[1082]	Lower San Pedro.	Pleistocene

Remarks: The single head valve seen seems to be conspecific with a similarly unique recent specimen at hand from Pacific Grove, which I recently ventured to describe as new under the name given above. It is also very near to another recent species lately described from Southern California, the *C. lowei* (Pilsbry), but the fossil agrees rather better in its lack of lines of pores in the articulamentum and in the more solid nature of the eaves and other parts of the shell, with the Pacific Grove form.

[8] It has been necessary to draw a portion of this description from a recent specimen.

Genus **Lepidochitona** Gray, 1821

6. **Lepidochitona dentiens** (Gould, 1846)

(Plate I, figs. 7-9.)

1846. *Chiton dentiens* Gould, Proc. Bost. Soc. Nat. Hist., v. 2, p. 145.
1852. *Chiton (Onithochiton) dentiens* Gould, Moll. U. S. Expl. Exped., p. 321, pl. 28, f. 433-433b.
1857. *Chiton (?) dentiens* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1856, pp. 209, 318, 348.
1862. *Chiton dentiens* Gould, Otia Conch., p. 6.
1864. *Trachydermon pseudodentiens* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, pp. 530, 606, 612, 649.
1865. *Ischnochiton (Trachydermon) pseudodentiens* Carpenter, Proc. Acad. Nat. Sci., Phila., 1865, p. 60.
1879. *Trachydermon dentiens* Dall, Proc. U. S. Nat. Mus., v. 1, p. 323.
1892. *Ischnochiton (Trachydermon) dentiens* Pilsbry, Man. Conch. (1), v. 14, p. 73, pl. 8, f. 61-65.
1893. *Trachydermon dentiens* Pilsbry, Man. Conch., (1), v. 15, p. 65, pl. 15, f. 26 (girdle scales).
not 1917. *Trachydermon dentiens* Chace, Lorquinia, v. 2, p. 30 (=*Mopalia acuta*).

Diagnosis: Valves small, delicate, low, median ones more or less obscurely beaked; sculpture consisting of numerous low, flat, round, even granules over the entire surface, showing more or less tendency to form into longitudinal lines on the central areas; lateral areas fairly well defined in good material; sutural laminæ wide and low, separated by a moderately wide but shallow sinus; tegmental border of median valves gently arcuate in front; teeth thin, sharp, barely projecting, in tail valve very numerous and often bifid; eaves spongy; mucro a little anterior of the middle, rather elevated, its posterior slope concave; slits 11, 1-1, 10 to 15.

Recorded Range:

Pleistocene: Lower San Pedro Series—Nob Hill Cut, San Pedro, California (!).

Living: Esquimalt, British Columbia (Carpenter), to Socorro Island, Revillagigedo Group, Mexico (Pilsbry); between tides.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
57	Int..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[659]	Lower San Pedro...	Pleistocene
5	Int..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Berry Coll. Cat. 4122.	[659]	Lower San Pedro...	Pleistocene
?1	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[711]	?	?Pleistocene

Remarks: The sculpture of *L. dentiens* is extremely similar to that of *Cyanoplax raymondi* (Pilsbry), but the short, wide valves, delicate structure of the shell, and short sutural laminæ lead me to refer the fossil specimens to the former species. Mr. and Mrs. Oldroyd obtained it so abundantly in the Nob Hill Cut that it seems strange that, except for one perhaps questionable specimen from Deadman Island, it has not been detected in any of the other horizons. The specimens are so fragile that none were obtained in an altogether perfect condition, but in spite of this and the lack of any terminal valves in the series, the identification seems reasonably certain.

Genus **Nuttallina** Carpenter, 1879

7. **Nuttallina californica** (Nuttall, 1847)

(Plate III, figs. 1-12.)

1847. *Chiton californicus* Nuttall in Reeve, Conch. Icon., v. 4, Chiton, sp. 90, pl. 16, f. 90; detail pl., f. 89.

1864. *Acanthopleura scabra* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, p. 527, 603, 649.

1893. *Nuttallina californica* Pilsbry, Man. Conch., (1), v. 14, p. 279, pl. 54, f. 23-24; pl. 56, f. 12-18.

1919. *Nuttallina* cf. *fluxa* Chace and Chace, Lorquinia, v. 2, p. 42 [2] (recorded from Pleistocene of Pt. Fermin, Cal.).

Diagnosis: Valves heavy, low, more or less triangular, median ones strongly beaked, though beaks and entire posterior portion often lost by erosion; sculpture comprising a narrow sulcus bounding the jugal tract on each side, an oblique ridge dividing the lateral and pleural areas, and a coarse, rather zig-

zag granulation over the two latter regions, the jugal tract smooth; traces of the color pattern of white jugal triangles often persistent, these giving way rather abruptly on the sides to brown; sutural laminæ very long, pointed on the inner front margin, the wide sinus steep-sloped and deep; tegmental border of median valves strongly arcuate in front; teeth of head valve long and projecting, of median valves very weakly developed, of tail valve low, thickened, very irregular in width, and strongly directed forward; eaves and sinus spongy; mucro strongly posterior, often overhanging; slits 10 to 11, 1-1 (though with slit-rays 2-2), 7 to 9.

Recorded Range:

Pleistocene: Lower San Pedro Series — Chiton Bed, Point Fermin, California (!); Nob Hill Cut, San Pedro, California (!).

Formation doubtful—Deadman Island, San Pedro, California (!).

Living: Vancouver Island, British Columbia (Pilsbry), to Piedras Blancas, San Luis Obispo County, California (Pilsbry); between tides.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
5	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Chace Coll.....	[944]	Lower San Pedro...	Pleistocene
3	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4040	[1026]	Lower San Pedro...	Pleistocene
31	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4040	[1027]	Lower San Pedro...	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4040	[1028]	Lower San Pedro...	Pleistocene
20	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4040	[1083]	Lower San Pedro...	Pleistocene
3	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4040	[1084]	Lower San Pedro...	Pleistocene
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1361]	Lower San Pedro...	Pleistocene
6	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1362]	Lower San Pedro...	Pleistocene
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Berry Coll. Cat. 4964	[1362]	Lower San Pedro...	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1363]	Lower San Pedro...	Pleistocene
3	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Berry Coll. Cat. 4964.....	[1403]	Lower San Pedro...	Pleistocene
71	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Cal. Aed. Sci.....	[1404]	Lower San Pedro...	Pleistocene
11	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Chace Coll.....	[1405]	Lower San Pedro...	Pleistocene
1	Ant..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[652]	Lower San Pedro...	Pleistocene
1	Int..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[653]	Lower San Pedro...	Pleistocene
2	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[678]	Lower San Pedro...	Pleistocene

Remarks: Specimens of *Nuttallina* are far from widely distributed as fossils in spite of their present day abundance. I have seen them in numbers only from the Point Fermin "Chiton

Bed". The two principal living species are very similar to each other but are supposed to be quite distinctly separable geographically, *N. californica* occurring from the neighborhood of Point Concepcion as far north, perhaps, as British Columbia, while *N. fluxa* (Carpenter) is recorded from Southern and Lower California.

When first received the median valve figured was thought to be referable to *N. fluxa* rather than to *N. californica*. Receipt of better material has caused me to revise this opinion, but I must admit that even with recent material I am not always confident that I am able to draw a proper dividing line between these two species. The *fluxa*-like outline of the specimen under consideration, however, seems clearly due to the erosion of the entire posterior portion of the valve. It has the following caliper measurements: length 5.3, diameter 6.8, alt. 3.6 mm.

The largest perfect specimen seen is an intermediate valve from the Chiton Bed [1027], and measures: length 8.7, diameter 9.0, alt. 3.2 mm. A worn and eroded median valve from the same exposure [1404] is much larger, its length 12.0, diameter 16.7, and alt. 5.8 mm.

Family **Mopaliidæ**

Genus **Mopalia** Gray, 1847

8. **Mopalia muscosa** (Gould, 1846)

(Plate IV, figs. 1-9.)

1846. *Chiton muscosus* Gould, Proc. Bost. Soc. Nat. Hist., v. 2, p. 145.

1847. *Chiton ciliatus* Reeve, Conch. Icon., v. 4, Chiton, sp. 124, pl. 19, f. 124; detail pl., f. 124 (not of Sowerby, 1840).

1847. *Chiton collei* Reeve, id., sp. 136, pl. 21, f. 136.

1852. *Chiton muscosus* Gould, Moll. U. S. Expl. Exped., p. 313, f. 436.

1862. *Chiton muscosus* Gould, Otia Conch., p. 6.

1893. *Mopalia muscosa* Pilsbry, Man. Conch., (1), v. 14, p. 295, pl. 63, f. 46-56; pl. 64, f. 74.

1903. *Mopalia ciliata* Arnold, Mem. Cal. Ac. Sci., v. 3, p. 28, 42, 85, 343 (recorded from Pleistocene of San Pedro, Cal.).

1906. *Mopalia ciliata* Arnold, Pectens of Calif., p. 36 (recorded from Pleistocene of San Pedro, Cal.).

1919. *Mopalia muscosa* Chace and Chace, Lorquinia, v. 2, p. 42 [2] (recorded from Pleistocene of Pt. Fermin, Cal.).

Diagnosis: Valves moderately heavy, barely beaked; lateral areas distinct, bounded by a strong rib-like series of more or less overlapping tubercles in front, and a similar but more or less obsolete series of wider tubercles on the sutural margin, the area between closely and finely tubercular; head valve similarly sculptured with 8 strongly tuberculose radial ridges in addition to the tubercled thickenings on the sutural margin; central areas sculptured throughout with numerous low, rather crenulate, longitudinal riblets, sometimes weakly interlatticed by traces of a fine radial liration across the sulci; sutural laminæ low and broad, the sinus rather shallow; tegmental border of median valves with a distinct, obtusely rounded, beak-like projection in front; teeth of first 7 valves strongly projecting, those of head valve vertically grooved outside; tail valve with a single pair of lateral slits and a small angular sinus in the articulamentum which barely indents the tegmental border; mucro low and strongly posterior; eaves spongy and crenulated; slit formula 8, 1-1, 1-1.

Recorded Range:

Pleistocene: Lower San Pedro Formation—Chiton Bed, Point Fermin, California (Chace and Chace, !); Nob Hill Cut, San Pedro, California (!).

Upper San Pedro Formation—"Crawfish George's", San Pedro, California (!); "lumber yard", San Pedro, California (Arnold, as *ciliata*); "coal mine", Point Loma, California (!).

Formation doubtful—Deadman Island, San Pedro, California (!).

Indian middens: Near Cypress Point, Monterey County, California (!); mouth of Topanga Canyon, near Santa Monica, California (Dr. F. C. Clark, Coll., !); La Jolla, California (!).

Living: Shumagin Islands, Alaska (Dall), to Cedros Island, Lower California; usually between tides.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
2	Ant.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4041.	[1034]	Lower San Pedro...	Pleistocene
1	Ant.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Cal. Acd. Sci.....	[1088]	Lower San Pedro...	Pleistocene
1	Int.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Berry Coll. Cat. 4041.	[945]	Lower San Pedro...	Pleistocene
12	Int.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Chace Coll..... Berry Coll. Cat. 4041	[1035]	Lower San Pedro...	Pleistocene
5	Int.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Cal. Acd. Sci..... Berry Coll. Cat. 4105	[1089]	Lower San Pedro...	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat.4105.	[1090]	Lower San Pedro...	Pleistocene
4	Int.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1364]	Lower San Pedro...	Pleistocene
3	Ant.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Chace Coll.....	[1406]	Lower San Pedro...	Pleistocene
14	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Chace Coll.....	[1407]	Lower San Pedro...	Pleistocene
1	Ant.	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[654]	Lower San Pedro...	Pleistocene
2	Int.	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll	Dept. Geology, Stanford Univ.....	[655]	Lower San Pedro...	Pleistocene
1	Post.	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[656]	Lower San Pedro...	Pleistocene
?2	Ant.	Crawfish George's, San Pedro, Cal.....	E. P. Chace, 1918.....	Berry Coll. Cat. 4046.	[952]	Lower San Pedro...	Pleistocene
1	Int.	Crawfish George's, San Pedro, Cal.....	E. P. Chace, 1918.....	Berry Coll. Cat. 4046.	[953]	Lower San Pedro...	Pleistocene
?1	Int.	Crawfish George's, San Pedro, Cal.....	E. P. Chace, 1918.....	Berry Coll. Cat. 4046.	[953]	Lower San Pedro...	Pleistocene
1	Int.	Coal mine, Pt. Loma, Cal...	C. L. Hubbs.....	Berry Coll. Cat. 3932.	[550]	Upper San Pedro...	Pleistocene
?4	Ant.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[689]	?	? Pleistocene
?1	Ant.	Deadman Id., San Pedro, Cal.	Arnold Coll	Dept. Geology, Stanford Univ.....	[697]	?	? Pleistocene
?12	Ant.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[719]	?	? Pleistocene
4	Int.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[690]	?	? Pleistocene
?2	Int.	Deadman Id., San Pedro, Cal.	R. Arnold, May, 1901....	Dept. Geology, Stanford Univ.....	[692]	?	? Pleistocene
?2	Int.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[702]	?	? Pleistocene
?1	Int.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[729]	?	? Pleistocene
?1	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[703]	?	? Pleistocene
?1	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[721]	?	? Pleistocene

Remarks: Valves of this species are not always easy to discriminate from those of several of its living allies, especially as they are so often worn and broken. Well preserved specimens should be quite readily identifiable by their coarse sculpturing, the longitudinal ribs of the central areas being heavier and fewer than in such species as *M. hindsii*, while the ribs bounding the central areas, as well as these areas themselves, are more strongly granose. In shape the valves are generally quite elevated and have an unusually shallow jugal sinus.

Dall and Pilsbry have already called attention to the fact that in this species the tegmentum of the median valves has a sort of rounded, false beak in the middle in front, which is an

aid in the separation of the species from *M. ciliata,* but this beak is sometimes eroded away in fossils.

Practically all the fossil Mopalias will require re-examination after those of the recent fauna have become better understood than they are at present.

9. **Mopalia hindsii** (Sowerby, 1847)

(Plate IV, figs. 10-12.)

1847. *Chiton Hindsii* Sowerby, in Reeve, Conch. Icon., v. 4, Chiton, sp. 67, pl. 12, f. 67a-b; detail pl., f. 67.

1847. *Mopalia Hindsii* Gray, Proc. Zool. Soc. Lond., p. 69, 169.

1893. *Mopalia muscosa* var. *hindsii* Pilsbry, Man. Conch., (1), v. 14, p. 296, pl. 62, f. 99-100; pl. 63, f. 57.

1916. *Mopalia hindsii* Chace, Nautilus, v. 30, p. 71 (recorded from Pleistocene of Deadman Id., Cal.).

Diagnosis[9]: Valves moderately heavy, barely beaked; lateral areas distinct, bounded in front by a low, sometimes obsolete, rather indistinctly granose rib, and behind by a much weaker sutural thickening, the area between showing an interwoven basket-like pattern of varying distinctness; head valve similarly ornamented with 8 low, indistinctly granose, radiating ribs, showing the basket-like sculpturing between; central areas sculptured with numerous fine longitudinal riblets, either weakly interlatticed, or so broken as to have a zigzag appearance, sometimes nearly obsolete; jugal tracts with a sharp longitudinal divergent ribbing, or with sculpture obsolete; sutural laminæ low and broad; sinus narrow and rather shallow; tegmental border of median valves with a distinct, rounded beak-like projection in front; teeth of head valve moderately long, rather weakly vertically grooved outside; teeth of median valves projecting, less distinctly grooved; tail valve with a single pair of lateral slits and an angular posterior sinus in the articulamentum, the tegmentum rather broadly emarginate above it; mucro a little behind the center; eaves spongy and somewhat crenulate; slits 8, 1-1, 1-1.

[9] Description drawn in part from recent specimens.

Recorded Range:

Pleistocene: Formation doubtful—Deadman Island, San Pedro, California (Chace, !).

Living: Forrester Island, Alaska, (!) to Ventura County, California (!); usually between tides, but recorded to 30 fathoms. Also recorded from Laguna Beach, Orange County, California (Guernesey), and San Diego, California (Kelsey).

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	ii....	Deadman Id., San Pedro, Cal.	E. P. Chace.....	Berry Coll. Cat. 3935.	[578]	—San Pedro.....	Pleistocene
1	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[691]	?	? Pleistocene

Remarks: One of the two specimens here referred to *M. hindsii* is that previously reported from the San Pedro Formation by Chace. While I am unable to place it elsewhere, it nevertheless does not seem to be entirely characteristic for this species. In this specimen even the central areas have a beautiful basket-like, interwoven appearance to the sculpturing, something like that of the lateral areas but finer. It has been found hopeless to depict this with any real faithfulness in a stipple drawing, but perhaps the illustration will give a hint of what is meant. In all recent specimens I have examined, as well as in the fossil from the Arnold collection, the longitudinal sculpture of the central areas is much more marked and results in an effect of fine, rather wavy fluting, instead of interweaving. The divergent riblets on the jugal area of the second valve are generally quite well marked. On the other valves this is less evident.

Well preserved specimens are readily distinguished from all forms of *M. muscosa* by the peculiar cloth-like sculpturing, and the usually flatter outline. In living specimens the girdle characters of the two species are widely different.

10. **Mopalia acuta** (Carpenter, 1855)

(Plate V, figs. 10-11.)

1855. *Chiton acutus* Carpenter, Proc. Zool. Soc. Lond., 1855, p. 232.

1864. *Mopalia acuta* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, p. 527, 648.

1893. *Mopalia muscosa* var. *acuta* Pilsbry, Man. Conch., (1), v. 14, p. 297, pl. 64, f. 75-81.

1917. *Trachydermon denticus* Chace, Lorquinia, v. 2, p. 30 (*not Chiton denticus* of Gould; recorded from Pleistocene of Santa Monica, California).

Diagnosis: Valves small to moderate in size, rather delicate; sculptured in similar fashion to *M. lignosa*, but the sutural rib in valves i-vii typically ornamented by series of delicate denticles; sutural laminæ short and wide; sinus narrow and rather shallow; tegmental border of median valves weakly

Fig. 9

Fig. 9. *Mopalia acuta* (Carpenter). Anterior elevation of valve illustrated in Plate V, figs. 10-11; camera outline.

false-beaked in front; teeth rather short, only moderately projecting; tail valve with a single pair of lateral slits, one or more of which may be duplex, and a small posterior sinus, often showing a small tooth at the apex; eaves spongy; slits 8, 1-1, 1-1.

Recorded Range:

Pleistocene: Lower San Pedro Series—Nob Hill Cut, San Pedro, California (!).

Upper San Pedro Series—Long Wharf Canyon, Santa Monica, California (!); Los Cerritos Hill, Long Beach, California (!).

Formation doubtful—Deadman Island, San Pedro, California (!).

Living: Monterey, California (!) to Todos Santos Bay, Lower California (!)[10].

[10] The record by Baker from Ellamar, Alaska, surely requires confirmation.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
21	Int..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.	Dept. Geology, Stanford Univ... Berry Coll. Cat. 3971	[657]	Lower San Pedro...	Pleistocene
1	Post.	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.	Dept. Geology, Stanford Univ.....	[658]	Lower San Pedro...	Pleistocene
?2	Ant..	Deadman Id., San Pedro, Cal.	Arnold Coll.	Dept. Geology, Stanford Univ.....	[693]	?	? Pleistocene
?12	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.	Dept. Geology, Stanford Univ.....	[695]	?	? Pleistocene
?2	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.	Dept Geology, Stanford Univ.....	[696]	?	? Pleistocene
?1	Ant..	?Deadman Id., San Pedro, Cal.	Oldroyd Coll.	Dept. Geology, Stanford Univ.....	[673]	?"Upper San Pedro"	Pleistocene
?1	Post.	?Deadman Id., San Pedro, Cal.	Oldroyd Coll.	Dept. Geology, Stanford Univ.....	[674]	?"Upper San Pedro"	Pleistocene
3	Ant..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark.	F. C. Clark Coll.....	[760]	Upper San Pedro...	Pleistocene
4	Int..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark.	F. C. Clark Coll.....	[761]	Upper San Pedro...	Pleistocene
1	Int..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark.	Berry Coll. Cat. 3966.	[762]	Upper San Pedro...	Pleistocene
1	Int..	Los Cerritos Hill, Long Beach, Cal.	T. S. Oldroyd.	Dept. Geology, Stanford Univ.....	[665]	Upper San Pedro...	Pleistocene

Remarks: Specimens of a nearly smooth *Mopalia*, believed for the most part to be identical with the recent *M. acuta* (Carpenter), have been seen from several horizons, but the material is frequently so poor that one cannot be absolutely certain of the identification, especially since the recent forms themselves belonging to this group are still very insufficiently known. Most of the specimens are very small, and this, with the yellow-brown maculation still visible now and then, gives support to the view that they are not forms of *lignosa*. On the other hand only one or two of the valves possess even a trace of the delicate sutural denticulation supposedly characteristic of *acuta*, the sutural margin in most instances being smooth. The largest of the specimens listed [695] is but 15.8 mm. in diameter. The largest of the Long Wharf Canyon specimens [762], which is believed to be more surely identified, has a diameter of only 9.2 mm. The largest of those from the Nob Hill Cut [657] is 12.3+ mm. in diameter. These two lots at least, as well as the specimen from Los Cerritos Hill, appear to represent the same species, but it may be that some of the Deadman Island specimens are really young *lignosa*.

11. **Mopalia lignosa** (Gould, 1846)

1846. *Chiton lignosus* Gould, Proc. Bost. Soc. Nat. Hist., v. 2, p. 142.
1846. *Chiton Merckii* Middendorff, Bull. Imp. Ac. Sci. St. Petersb., v. 6, p. 20.
1846. *Chiton Eschscholtzii* Middendorff, id., p. 118.
1847. *Chiton Merckii* Middendorff, Malac. Ross., v. 1, p. 114, pl. 11, f. 5-6.
1847. *Chiton Eschscholtzii* Middendorff, id., p. 114, pl. 11, f. 4.
1847. *Mopalia Simpsoni* Gray, Proc. Zool. Soc. Lond., 1847, p. 69 (teste Carpenter; name only).
1852. *Chiton vespertinus* Gould, Moll. U. S. Expl. Exped., p. 323, f. 426-426a.
1855. *Chiton montereyensis* Carpenter, Proc. Zool. Soc. Lond., 1855, p. 231.
1862. *Chiton lignosus* Gould, Otia Conch., p. 3.
1862. *Chiton (Chaetopleura) vespertinus* Gould, Otia Conch., p. 230, 242.
1864. *Mopalia lignosa* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, p. 530, 533, 554, 598, 648.
1879. *Mopalia ciliata lignosa* Dall, Proc. U. S. Nat. Mus., v. 1, p. 304.
1893. *Mopalia muscosa lignosa* Pilsbry, Man. Conch., (1), v. 14, p. 299, pl. 63, f. 58-59.
1919. *Mopalia lignosa* Chace and Chace, Lorquinia, v. 2, p. 42 [2] (recorded from Pleistocene of Point Fermin, California).

Diagnosis[11]: Valves of moderate thickness, barely beaked; lateral areas usually distinct, bounded in front by a low, often more or less obsolete diagonal rib; head valve bearing 8 similar, low, radial ribs; entire surface of all valves between ribs covered by a very fine latticed ribbing showing small pit-like interstices, sometimes with sculpture nearly obsolete; traces of brownish or grayish flammules sometimes still persistent; sutural laminæ low and broad; sinus narrow and rather shallow; tegmental border in median valves with a distinct, rounded, median, beak-like projection in front; teeth of head valve projecting, moderately long, sharply beveled and more or less grooved at edges; teeth of median valves projecting, less dis-

[11] Description drawn in considerable part from recent specimens.

tinctly beveled or grooved; tail valve with a single pair of lateral slits and a small posterior sinus, often showing a minute tooth at its apex; eaves spongy; slits 8, 1-1, 1-1.

Recorded Range:

Pleistocene: Lower San Pedro Series—Chiton Bed, Point Fermin, California (Chace and Chace, !); near lighthouse, Point Fermin, California (!).

Formation doubtful— ? Deadman Island, San Pedro, California (!).

Living: Sitka, Alaska, to Morro, San Luis Obispo County, California (!); also reported from Point Fermin, Los Angeles County, California (Williamson); usually between tides, but recorded to 30 fathoms.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	Chiton Bed, Pt. Fermin, Cal..	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4078.	[1039]	Lower San Pedro...	Pleistocene
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Chace Coll.....	[1410]	Lower San Pedro...	Pleistocene
1	Post.	Near lighthouse, Pt. Fermin, Cal.....	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4109.	[1100]	Lower San Pedro...	Pleistocene
1	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[694]	?	? Pleistocene
?1	Ant..	?Deadman Id., San Pedro, Cal.	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[672]	?"Upper San Pedro"	Pleistocene

Remarks: Several fossil valves seem referable to this species, as they are not only of a size commensurate with that of recent *lignosa,* but when moistened still exhibit distinct traces of the peculiar flamed color pattern so characteristic of the shell of the living animal. The largest entire specimen [694] has a diameter of 21.2 mm.

The condition of none of the material at hand is such as to render an illustration worth while.

12. **Mopalia ciliata** (Sowerby, 1840)

(Plate V, figs. 1-9.)

1840. *Chiton ciliatus* Sowerby, Ann. Mag. Nat. Hist (n.s.), v. 4, p. 289.

1840. *Chiton ciliatus* Sowerby, Conch. Ill., fig. 79.

1864. *Mopalia Kennerleyi* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, p. 648.

1864. *Mopalia Kennerleyi* var. *Swanii* Carpenter, id., p. 627, 648.

1864. *Mopalia Kennerleyi* var. *Swannii* Carpenter, Ann. Mag. Nat. Hist., (3), v. 14, p. 426.

1865. *Mopalia Kennerleyi* Carpenter, Proc. Acad. Nat. Sci. Phila., 1865, p. 59.

1879. *Mopalia Wossnessenskii* Dall, *(pars)* Proc. U. S. Nat. Mus., v. 1, p. 305.

1893. *Mopalia ciliata* Pilsbry, Man. Conch., (1), v. 14, p. 303. pl. 64, f. 64-68.

1919. *Mopalia ciliata* Chace and Chace, Lorquinia, v. 2, p. 42 [2] (recorded from Pleistocene of Pt. Fermin, Cal.).

Diagnosis: Valves moderately heavy, rather distinctly beaked; lateral areas distinct, bounded by a low, granose rib in front, and with the sutural margin also more or less granose, the area between filled with rows of smaller grains; head valve similarly sculptured, bearing 8 radial series of low tubercles; pleural tracts somewhat excavated, sculptured by numerous fine, sinuous, rather granular, weakly interlatticed, longitudinal riblets, the jugal tract with sharper, finer and closer sculpture; sutural laminæ and teeth long and projecting; sinus wide and spongy; tegmental border of median valves sinuous in front, but not false beaked; tail valve with a single pair of lateral slits and a large, rounded, posterior sinus; mucro well behind the middle; eaves spongy and crenulated; slits 8, 1-1, 1-1.

Recorded Range:

Pleistocene: Lower San Pedro Series — Chiton Bed, Point Fermin, California (Chace and Chace, !); near lighthouse, Point Fermin, California (!).

Formation doubtful—Deadman Island, San Pedro, California (!).

Living: Aleutian Islands (Keep), to Todos Santos Bay, Lower California (!); between tides and to 50 fathoms.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Cal. Acd. Sci.....	[1036]	Lower San Pedro...	Pleistocene
1	Ant..	Chiton Bed, Pt. Fermin, Cal..	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4077.	[1036]	Lower San Pedro...	Pleistocene
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4077.	[1037]	Lower San Pedro...	Pleistocene
2	Int..	Chiton Bed, Pt, Fermin, Cal.	E. P. & E. M. Chace, 1918	Cal. Acd. Sci.....	[1037]	Lower San Pedro...	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4077.	[1038]	Lower San Pedro...	Pleistocene
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Chace Coll.....	[1408]	Lower San Pedro...	Pleistocene
3	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Chace Coll.....	[1409]	Lower San Pedro...	Pleistocene
1	Ant..	Near lighthouse, Pt. Fermin, Cal.....	E. P. & E. M. Chaee, 1918	Berry Coll. Cat. 4108.	[1098]	Lower San Pedro...	Pleistocene
4	Int..	Near lighthouse, Pt. Fermin, Cal.....	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4108.	[1099]	Lower San Pedro...	Pleistocene
6	Ant..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[727]	?	? Pleistocene
17	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[698]	?	? Pleistocene
?2	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Berry Coll. Cat. 5183.	[700]	?	? Pleistocene
2	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[699]	?	? Pleistocene
1	Post..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Berry Coll. Cat. 5183.	[701]	?	? Pleistocene
1	Ant..	? Deadman Id., San Pedro, Cal.....	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[675]	?"Upper San Pedro"	Pleistocene
2	Int..	? Deadman Id., San Pedro, Cal.....	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[676]	?"Upper San Pedro"	Pleistocene
1	Int..	? Deadman Id., San Pedro, Cal.....	Oldroyd Coll.....	Berry Coll. Cat. 5181.	[676]	?"Upper San Pedro"	Pleistocene

Remarks: There are numerous *Mopalia* valves in the collections seen which have given more than their share of trouble to identify. Most of them are quite close to common forms of the recent *M. ciliata,* and one encounters little difficulty in so naming them. But other specimens appear to have an aspect of their own, especially two or three intermediate valves which show a peculiar, broad, triangular, finely longitudinally striate jugal area. There is also variation in several other directions so that a thorough revision of the recent forms may show that I have included more than one species here. For the present there is little to be done but follow Pilsbry in his redefinition of *ciliata.* He regards the common Monterey form as typical for Sowerby's species. If this be so, then some at least of the fossils are correctly determined. Head valves are probably the hardest to satisfactorily identify, as they so often closely resemble those of *M. muscosa.*

13. **Mopalia** cf. **sinuata** Carpenter, 1864

(Plate VI, figs. 7-8.)

1864. ? *Mopalia sinuata* Carpenter, Rep. Brit. Assoc. Adv. Sci. 1863, p. 648.

1865. ?*Mopalia sinuata* Carpenter, Proc. Acad. Nat. Sci. Phila., 1865, p. 59.
1879. *Mopalia sinuata* Dall, Proc. U. S. Nat. Mus., v. 1, p. 303, 306.
1886. *Placiphorella (Osteochiton) sinuata* Dall, Proc. U. S. Nat. Mus., v. 9, p. 211.
1893. *Mopalia sinuata* Pilsbry, Man. Conch., (1), v. 14, p. 303, pl. 62, f. 95-97.

Recorded range: Pleistocene (?): Deadman Island, San Pedro, California (!).

Living (sinuata): Forrester Island, Alaska (!), to San Francisco Bay, California (Newcomb); 0-30 fathoms.

Material Examined: A single anterior valve in the Arnold collection from Deadman Island, San Pedro, California [717], exact horizon unknown.

Remarks: The single specimen seen is remarkably close to the recent *Mopalia sinuata* Carpenter, and further material may confirm my surmise that it belongs to this northern species. The fossil agrees with recent shells in its relatively clean-cut, continuous ribs, and the peculiar, deeply pitted reticulum which occupies their interspaces, a sculpturing wholly unlike that of any other of the Mopalias thus far described. It is very unfortunate that the exact formation from which the specimen was taken is unknown.

14. **Mopalia**, sp. indet.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	Rustic Canyon, Santa Monica, Cal.	F. C. Clark	Berry Coll. Cat. 4052.	[957]	Santa Barbara	Pliocene
2	Ant..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	Berry Coll. Cat. 4002.	[931]	Upper San Pedro	Pleistocene
3	Ant..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	F. C. Clark Coll.	[932]	Upper San Pedro	Pleistocene
2	Int..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	Berry Coll. Cat. 4002.	[933]	Upper San Pedro	Pleistocene
7	Int..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	F. C. Clark Coll.	[934]	Upper San Pedro	Pleistocene
3	Post.	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	F. C. Clark Coll.	[935]	Upper San Pedro	Pleistocene
1	Post.	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	Berry Coll. Cat. 4002.	[936]	Upper San Pedro	Pleistocene

Remarks: The 18 small *Mopalia* valves listed in the table above from the Pleistocene of Santa Monica are mostly in very mediocre condition and cannot be referred with certainty to any of the known species. The largest [934] has the following caliper measurements: long. 3.2; diam. 8.5; alt. 3.1 mm. Perhaps it is possible that the specimens represent juvenals of the foregoing species *(ciliata)* or even of *muscosa,* but further material is needed to settle the question. Where the sculpture is at all well preserved it is very sharp and beautiful. A single specimen of undoubtedly the same species is here recorded from the Pliocene of Rustic Canyon, Santa Monica. The Pliocene age of this specimen is therefore desirable of confirmation.

15. **Mopalia**, sp. indet.

A single badly worn intermediate valve of what seems to be an indeterminate Mopalia [954] is before me from Mr. Chace's collections at Crawfish George's (Lower San Pedro Pleistocene), San Pedro, California.

Genus **Placiphorella** Carpenter, 1879

16. **Placiphorella velata** Carpenter, 1879

(Plate III, figs. 13-15.)

1879. *Placiphorella velata* Carpenter in Dall, Proc. U. S. Nat. Mus., v. 1, pp. 298, 303, 307, pl. 4, f. 36-36a (radula).

1893. *Placiphorella velata* Pilsbry, Man. Conch., (1), v. 14, p. 306, pl. 66, f. 6-12.

1919. *Placiphorella velata* Chace and Chace, Lorquinia, v. 2, p. 43 [3] (recorded from Pleistocene of Pt. Fermin, Cal.).

Diagnosis[12]*:* Valves heavy, the median ones not beaked; straight or even distinctly concave behind, extremely short and wide; practically unsculptured except for the lines of growth; lateral areas distinct and well raised, separated into low ribs by a shallow central sulcus; tegmental border slightly false beaked in front; teeth of head valve short, numerous, primarily

[12] Description drawn in part from recent specimens.

with 8 slits, but in adult very imperfectly and irregularly developed, with numerous secondary slits; median valves with short but well projecting teeth and very wide sutural laminæ, continuous across the narrow, abrupt sinus; tail valve with a single pair of nearly obsolete lateral slits, rugose insertion plates, and weak or nearly obsolete, posterior sinus; mucro posterior; eaves spongy; slits 8+, 1-1, 1-1.

Recorded Range:

Pleistocene: Lower San Pedro Series—Chiton Bed, Point Fermin, California (Chace and Chace, !); near lighthouse, Point Fermin, California (!).

Formation doubtful—Deadman Island, San Pedro, California (!).

Living: Forrester Island, Alaska (!), to Todos Santos Bay, Lower California (!); between tides to 50 fathoms.

Material Examined:

No. 81 Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4106.	[1092]	Lower San Pedro...	Pleistocene
1	Ant.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Berry Coll. Cat. 4106.	[1358]	Lower San Pedro...	Pleistocene
1	Int.	Near lighthouse, Pt. Fermin, Cal.....	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4110.	[1101]	Lower San Pedro...	Pleistocene
1	Int.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[677]	?	? Pleistocene

Remarks: A valve in the Arnold collection from one of the Deadman Island formations is apparently referable to the bizarre *P. velata*, although it seems more than usually short and broad even for this species. Though somewhat chipped and worn it is on the whole in a very fair state of preservation, and is here figured. That the specimen is a second valve is indicated by the anteriorly projecting angle of the tegmentum and the very oblique insertion slits. It has the following caliper measurements: long. 7.0, diam. 26.7, alt. 8.4 mm.

Three valves, mainly fragmentary, from the Point Fermin exposures are the only additional fossil specimens which have been seen.

Genus **Katharina** Gray, 1847

17. **Katharina tunicata** (Wood, 1815)

(Plate VI, figs. 1-6)

1815. *Chiton tunicatus* Wood, Gen. Conch., p. 11, pl. 2, f. 1.
1828. *Chiton tunicatus* Wood, Index Test., p. 2, Chiton, pl. 1, f. 10.
1847. *Katharina tunicata* Gray, Proc. Zool. Soc. Lond., 1847, p. 69.
1893. *Katharina tunicata* Pilsbry, Man. Conch., (1), v. 15, p. 41, pl. 1, f. 1-11.
1919. *Katherina tunicata* Chace, Nautilus, v. 30, p. 71 (recorded from Pleistocene of Deadman Id., Cal.).

Diagnosis: Valves massive; tegmentum greatly restricted, more or less flask-shaped in the median valves, with an elongate, neck-like projection in front jutting into the sinus; areas not well delimited, except for the slightly elevated jugal tract extending back from the anterior process; sculpture obsolete except for the rather strong lines of growth and about 8 weak, radial ribs on the head valve; insertion plates in valves ii-viii coalescent with the immensely developed and flaring sutural laminæ, in valve i long with strong grooves radiating to short slits at the margin, in valve viii directed abruptly forward from the blunt, posteriorly projected mucro; articulamentum of tail valve with a distinct posterior sinus; eaves and sinus spongy; slits 8+, 1-1, 1-1.

Recorded Range:

Pliocene: Santa Barbara Formation—Deadman Island, San Pedro, California (!).

Pleistocene: Formation doubtful—Deadman Island, San Pedro, California (Chace, !).

Indian Middens: Near Cypress Point, Monterey County, California (!).

Living: Kamtschatka and Aleutian Islands to Santa Catalina Island, California; between tides, but occasionally to 20 fathoms (Pilsbry).

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[726]	Santa Barbara.....	Pliocene
1	Ant..	Deadman Id., San Pedro, Cal.	E. P. Chace.....	Berry Coll. Cat. 3936.	[345]	—San Pedro.....	Pleistocene

Remarks: The specimen previously reported by Chace from the Pleistocene of Deadman Island is the one before me. It is an anterior valve of this very peculiar and unmistakable species, the first to be reported in the fossil state, and perfect except for the loss of the tegmentum by delamination. The Arnold collection has since proved to contain a large and finely preserved intermediate valve of the same species from the Pliocene of this island. Mr. Chace seems to be reasonably positive that his specimen came from the Pleistocene and not from the Pliocene, though whether from the Upper or Lower San Pedro Series he cannot now be certain. The Stanford specimen has quite a different appearance lithologically and is plainly marked "Pliocene" on the accompanying label. The measurements of this specimen by caliper are: long, 22.8, diam. 26.7, alt. 8.5 mm. Both specimens are figured herewith.

Family ACANTHOCHITONIDÆ

Genus **Acanthochitona** Gray, 1821

18. **Acanthochitona avicula** (Carpenter, 1864)

(Plate VI, fig. 9)

1864. *Acanthochites avicula* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, p. 612, 650.

1866. *Acanthochites avicula* Carpenter, Proc. Cal. Ac. Nat. Sci., v. 3, p. 211.

1893. *Acanthochites avicula* Carpenter, Man. Conch., (1), v. 15, p. 24 (after Carpenter).

1893. *Acanthochites avicula* var. *diegoensis* Pilsbry, id., p. 25, pl. 12, f. 52-54.

Diagnosis[13]: Valves rather delicate, carinated, sharply beaked; pleural and terminal areas ornamented with a "snake-skin pat-

[13] Description drawn largely from recent specimens.

tern" of regular, flat, scale-like pustules; jugal tract sculptured with 8-12 (fewer in juvenile specimens), closely placed, low, flattened, diverging ribs, separated by narrow, incised grooves; sutural laminæ large, rounded; jugal sinus moderate; tail valve with mucro nearly median but strongly directed posteriorly; teeth very long and projecting, slit in only a little way; eaves scarcely developed; slits 5, 1-1, 1-1.

Recorded Range: Pleistocene: Upper San Pedro Series—Long Wharf Canyon, Santa Monica, California (!).

Living: 6 miles north of Santa Monica, California (E. P. Chace, coll.,!), to San Diego, California; between tides to 20 fathoms.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	Berry Coll. Cat. 4022.	[940]	Upper San Pedro...	Pleistocene

Remarks: A single fragment of a median valve, still showing, however, its characteristic sculpture, was among Dr. Clark's material from the Santa Monica Pleistocene. The condition of the specimen leaves much to be desired, but the scaly sculpturing of the central areas, reminding one of a bit of rattlesnake skin, is unlike that of any other of our chitons.

The species has not been previously recorded as a fossil, and even in the recent state it seems to have an unusually limited geographical range.

Genus **Cryptochiton** Middendorff, 1847
(also of Gray, 1847)

19. **Cryptochiton stelleri** (Middendorff, 1846)

(Plate VI, figs. 10-12.)

1846. *Chiton stelleri* Middendorff, Bull. Ac. Sci. St. Pétersb., VI, p. 116 (fide Pilsbry).

1847. *Chiton* (*Cryptochiton*) *stelleri* Middendorff, Malac. Ross., I, p. 93, pl. 1-9.

1849. *Chiton* (*Cryptochiton*) *stelleri* Middendorff, Mem. Acad. Imp. Sci. St. Pétersb., (6), v. 6, p. 101, 157 (fide Pilsbry).

1869. *Cryptochiton stelleri* Gabb, Paleont. Calif., II, p. 87.

1888. *Cryptochiton stelleri* Cooper, 7th Ann. Rep. Cal. State Miner., p. 237 (recorded from Quarternary of San Diego, Cal.).

1893. *Cryptochiton stelleri* Pilsbry, Man. Conch., (1), v. 15, p. 48, pl. 6, f. 6; pl. 7, f. 7-13.

1895. *Cryptochiton c. f. stelleri* Ashley, Proc. Cal. Acad. Sci. (2), v. 5. p. 327 (recorded from Neocene of Purisima, Cal.)

1897. *Cryptochiton stelleri* Heath, Proc. Acad. Nat. Sci. Phila., 1897, p. 299 (description of young stage).

1903. *Cryptochiton stelleri* Arnold, Mem. Cal. Acad. Sci., v. 3, pp. 15, 19, 40, 68, 85, 342 (recorded from Pliocene and Pleistocene of San Pedro, Cal.).

1906. *Cryptochiton stelleri* Arnold, Pectens of Calif., pp. 31, 35 (listed from Pliocene and Pleistocene of San Pedro, Cal.).

Diagnosis: Valves large, solid, heavy; visible tegmentum entirely wanting in all later stages of growth; both anterior and posterior outlines of valves ii-viii bilobate; jugal sinus very deep; tail valve with a well developed posterior sinus; slits 4 to 7, 1-1, 1-1.

Recorded Range:

Pliocene: Purisima Formation—Purisima, California (Ashley). San Diego Formation—Pacific Beach, California (!).

Santa Barbara Formation—Deadman Island, San Pedro, California (Arnold).

Pleistocene: Lower San Pedro Series—Deadman Island, San Pedro, California (Arnold); Nob Hill Cut, San Pedro, California (!); Chiton Bed, Point Fermin, California (!).

Upper San Pedro Series—"Coal mine", West side of Point Loma, California (!); C. A. S. Loc. 108, 2 miles north of Point Loma, California (!).

Formation doubtful—San Diego, California (Cooper).

Indian middens: La Push, Washington (Reagan); near Cypress Point, Monterey County, California; San Nicolas Island, California (!).

Living: Northern Japan, Sakhalin, Kuril Islands, Kamtschatka, and Bering Sea, to Monterey Bay and the Santa Barbara Islands, California.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int.	Pacific Beach, Cal.	Mrs. Kate Stephens	Berry Coll. Cat. 112	[505]	San Diego	Pliocene
4	Int.	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.	Dept. Geology, Stanford Univ.	[643]	Lower San Pedro	Pleistocene
2	Post.	Nob Hill Cut, San Pedro, Cal.		Berry Coll. Cat. 3972	[644]	Lower San Pedro	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920	Berry Coll. Cat. 4944	[1359]	Lower San Pedro	Pleistocene
1	Ant.	Loc. 108, 2 mi. N. of Pt. Loma, Cal.	Cal. Acd. Sci.	Cal. Acd. Sci.	[517]	Upper San Pedro	Pleistocene
1	Int.	"Coal Mine," W. side Pt. Loma, Cal.	C. L. Hubbs	S. Diego. Soc. Nat. Hist.	[506]	Upper San Pedro	Pleistocene

Remarks: This characteristically boreal Pacific species is not common in any of the formations where it has been reported to occur. The large size and massive formation of the valves, however, render it a difficult species to overlook, and hence we find that it has been reported from more horizons in the area studied than any other chiton. Its occurrence in the Point Loma Pleistocene in the same exposure as the decidedly southern *Ischnochiton acrior* came as a distinct surprise.

I have been unable to differentiate any of the fossil shells from the recent ones morphologically in any way. One of the fossil specimens, however, a head valve in the collection of the California Academy of Sciences [517], is remarkable for the fact that the calloused inner layer of the shell has been entirely delaminated, exposing the internal and usually invisible radial grooves and concentric growth lines with exquisite perfection (Pl. VI, f. 10). Of the radial grooves, the six posterior radiate toward, and as usual are in correspondence with, the insertion slits. Another pair of grooves diverges anteriorly on each side of the sinus. Caliper measurements of this specimen are: Max. long. 27.2, max. diam. 32.1, alt. 10.0 mm.

Family **Ischnochitonidæ**

Subfamily **Chætopleurinæ**

Genus **Chætopleura** Shuttleworth, 1853

Subgenus **Pallochiton Dall, 1879**

20. **Chætopleura (Pallochiton) gemma** Carpenter, 1879

(Plate VIII, figs. 10-12.)

1879. *Chætopleura gemma* Carpenter, in Dall, Proc. U. S. Nat. Mus., v. 1, p. 296, pl. 1, f. 9 (radula).

1892. *Chætopleura gemmea* Pilsbry, Man. Conch., (1), v. 14, p. 31, pl. 13, f. 69-74.

1919. *Chætopleura gemma* Chace and Chace, Lorquinia, v. 2, p. 42 [2] (recorded from Pleistocene of Pt. Fermin, California).

Diagnosis[14]*:* Valves small, elevated, of moderate thickness, the median ones but weakly beaked, yet leaning strongly backward; lateral areas elevated, ornamented with 5-8 radiating series of small, strong, closely placed, projecting, cylindrical pustules, fewer in young shells; head valve similarly sculptured with very numerous (25-35) series of pustules, usually abraded toward the apex; central areas with 12-18 narrow, rather irregularly beaded, longitudinal liræ; tail valve with slightly raised, posterior mucro, the posterior slope steeply terraced and irregularly tubercled; sutural laminæ short; sinus wide, rather deep and angular; tegmentum projecting over and under articulamentum at suture, especially toward middle of median valves, where such inner surface is even more or less pustulose; teeth short and robust, slightly projecting; eaves roughened, but apparently not spongy; slits 9 to 12, 1-1, 7 to 8.

Recorded Range:

Pleistocene: Lower San Pedro Series—Chiton Bed, Point Fermin, California (Chace and Chace, !).

Living: Straits of Georgia, British Columbia (!), to Cedros Island, Lower California (Lowe); between tides to 15 fathoms.

[14] Description drawn in part from recent specimens.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4074.	[1025]	Lower San Pedro...	Pleistocene
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1921.....	Chace Coll.....	[1411]	Lower San Pedro...	Pleistocene

Remarks: Though so common at the present day, even if often somewhat local, along almost the entire coast of California, this very ornate little species is here recognized for the first time as a fossil. The specimens seen are intermediate valves and too characteristic in their well preserved sculpture to be readily mistaken.

The extraordinary extension of the recent range of the species as quoted by me above is based on a specimen [597] given me by Mr. Will F. Thompson, who collected it between tides in the Straits of Georgia.

The specific name is commonly written in the adjective form, *gemmea,* but as the originally published spelling is permissible as a substantive noun, it is here adopted.

Subfamily Ischnochitoninæ

Genus **Ischnochiton** Gray, 1847

Subgenus Stenoplax Carpenter 1879.

Section Stenoplax s. s.

21. Ischnochiton (Stenoplax) fallax Carpenter, 1892

(Plate VII, figs. 1-3)

1892. *Ischnochiton (Stenoplax) fallax* Carpenter, in Pilsbry, Man. Conch., (1), v. 14, p. 59, pl. 16, f. 17-18.

Diagnosis: Valves of moderate thickness, low, evenly arched, outline of all but the tail valve concave behind, not beaked; lateral areas strongly elevated, these and the terminal areas weakly sculptured by fine radial wrinkles and strongly terraced by the lines of growth; central areas very minutely, longitudi-

nally ribbed and pitted, usually worn almost smooth; tail valve large, with central mucro; sutural laminæ sinuous, triangular, with steep inner slopes; sinus wide, with a small notch at each side; teeth sharp and moderately long, but covered by the strongly projecting, solid eaves; slits 8 to 9, 1-1, 10 to 11.

Recorded Range:

Pleistocene: Lower San Pedro Series—Nob Hill Cut, San Pedro, California (!).

Formation doubtful—Deadman Island, San Pedro, California (!).

Living: Fort Bragg, California (!), to Santa Barbara Channel, California; shore to 15 fathoms.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[650]	Lower San Pedro...	Pleistocene
1	Post.	? Deadman Id., San Pedro, Cal.....	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[671]	?"Upper San Pedro"	Pleistocene
?1	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Berry Coll. Cat. 3969.	[683]	?	? Pleistocene

Remarks: The discovery of unmistakeable specimens of this little known Central California species in the southern fossil beds was a considerable surprise, but I feel reasonably confident of the identification. The peculiar features are the roundly arched outline and single slitting of the central valves, the terraced appearance of the lateral and terminal areas due to the very strong growth lines, the fine, wrinkly, radiating sculpture of these regions, and the very even and delicate ribbing and pitting of the central areas, though the ribs are hardly evident without a lens. All of these characteristics serve to separate *fallax* from *magdalenensis* and young *conspicuus,* with which it is alone likely to be confounded. Two of the fossils are beautifully preserved and check up well with the recent specimens, but the third is so badly worn there is perhaps some question regarding it.

Section Stenoradsia Carpenter, 1879

22. Ischnochiton (Stenoplax) magdalenensis (Hinds, 1844)

(Plate VII, figs. 4-10.)

1844. *Chiton magdalenensis* Hinds, Zool. Voy. "Sulphur", v. 2, p. 54, pl. 19, f. 1.

1864. *Ischnochiton Magdalensis* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, pp. 621, 649, 665.

1879. *Stenoradsia magdalenensis* Dall, Proc. U. S. Nat. Mus., v. 1, p. 296, 330, pl. 2, f. 12 (radula).

1888. *Ischnochiton magdalensis* Cooper, 7th Ann. Rep. Cal. State Miner., p. 244 (recorded from Quaternary of Santa Barbara, Cal.).

1892. *Ischnochiton (Stenoplax) magdalenensis* Pilsbry, Man. Conch., (1), v. 14, p. 62, pl. 15, f. 98-100.

1919. *Ischnochiton magdalenensis* Chace and Chace, Lorquinia, v. 2, p. 43 [3] (recorded from Pleistocene of Pt. Fermin, California).

Diagnosis: Valves of moderate thickness, depressed, subcarinate, all but the tail valve more or less concave behind, not beaked; lateral areas strongly elevated, these and the terminal areas ornamented by numerous fine ribs separated by rather sharp grooves, and interrupted to some extent by some of the lines of growth, yet not so conspicuously terraced as in *I. fallax;* central areas, where unworn, sculptured by numerous very fine anastomosing axial wrinkles, becoming more or less reticulated and pitted on the sides; slope of head valve straight or very weakly concave; tail valve large, with weakly projecting, central mucro; sutural laminæ long, triangular, slightly sinuous, with steep inner slopes; sinus wide, deep, notched at each side; teeth well developed, but surpassed by the projecting, solid eaves; slits 10 to 13, 2 to 4, 10 to 12.

Recorded Range:

Pleistocene: Lower San Pedro Series—Chiton Bed, Point Fermin, California (Chace and Chace, !); near lighthouse, Point Fermin, California (!).

Formation doubtful—Santa Barbara, California (Cooper); Deadman Island, San Pedro, California (!).

Living: Fort Bragg, California (!), to Magdalena Bay (and Cape San Lucas ?), Lower California.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Berry Coll. Cat. 4042	[946]	Lower San Pedro...	Pleistocene
2	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Berry Coll. Cat. 4042	[947]	Lower San Pedro...	Pleistocene
2	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Berry Coll. Cat. 4042	[948]	Lower San Pedro...	Pleistocene
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Chace Coll.....	[1031]	Lower San Pedro...	Pleistocene
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4105	[1085]	Lower San Pedro...	Pleistocene
10	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Chace Coll..... Berry Coll. Cat. 4076	[1032]	Lower San Pedro...	Pleistocene
7	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4105	[1086]	Lower San Pedro...	Pleistocene
4	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4105	[1087]	Lower San Pedro...	Pleistocene
5	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Chace Coll.....	[1033]	Lower San Pedro...	Pleistocene
1	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1365]	Lower San Pedro...	Pleistocene
7	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1365]	Lower San Pedro...	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1365]	Lower San Pedro...	Pleistocene
4	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....		[1412]	Lower San Pedro...	Pleistocene
16	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Berry Coll. Cat. 4965 Cal. Acd. Sci.....	[1413]	Lower San Pedro...	Pleistocene
5	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Chace Coll.....	[1414]	Lower San Pedro...	Pleistocene
6	Ant..	Near lighthouse, Pt. Fermin, Cal.....	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4111	[1102]	Lower San Pedro...	Pleistocene
16	Int..	Near lighthouse, Pt. Fermin, Cal.....	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4111	[1103]	Lower San Pedro...	Pleistocene
1	Post.	Near lighthouse, Pt. Fermin, Cal.....	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4111	[1104]	Lower San Pedro...	Pleistocene
2	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ....	[684]	?	Pleistocene

Remarks: Although in the living state this is one of the most abundant California chitons, I have been able to identify as this species scarcely any fossil material except that from the Lower San Pedro beds at Point Fermin. Both fossil and recent specimens are usually easy to differentiate from small specimens of the related forms, *acrior* and *conspicuus*, by the narrower, more elongate outline; the convex, straight, or (when perfect) very weakly concave head valve; the finely plicate sculpturing (often eroded) of the central areas, which becomes prettily netted toward the sides; and the numerous, fine, relatively straight, radiating riblets of the lateral and terminal areas. There are also girdle characters of value which are of course unavailable to the paleontologist.

23. **Ischnochiton (Stenoplax) conspicuus** (Carpenter, 1879)

(Plate VIII, figs. 1-9.)

1879. *Maugerella conspicua* Carpenter, in Dall, Proc. U. S. Nat. Mus., v. 1, p. 296, pl. 2, f. 11 (radula).

1892. *Ischnochiton (Stenoplax) conspicuus* Pilsbry, Man. Conch., (1), v. 14, p. 63, pl. 15, f. 91-96.

1914. *Ischnochiton conspicuus* Oldroyd, Nautilus, v. 28, p. 81 (recorded from Pleistocene of Signal Hill, Long Beach, Cal.).

1916. *Ischnochiton conspicuus* Chace, Nautilus, v. 30, p. 71 (recorded from Pleistocene of Deadman Island, Cal.).

1917. *Ischnochiton conspicuus* Chace, Lorquinia, v. 2, p. 30 (recorded from Pleistocene of Santa Monica, Cal.).

Diagnosis: Valves moderately heavy, large, depressed or moderately elevated, all but the tail valve slightly concave behind, not beaked; lateral areas strongly elevated, bearing fine, rather wrinkly, radial striæ of varying length, those of the terminal areas similar, but finer and often nearly obsolete: central areas sometimes weakly, longitudinally ribbed, but usually nearly smooth; head valve slightly everted at apex, its anterior slope strongly concave; tail valve large and flat, with low, central mucro; sutural laminæ long, triangular, slightly sinuous; sinus abrupt, deep, of moderate width, with a small notch on each side; teeth strong and sharp, but surpassed by the massive, projecting, solid eaves; slit 9 to 12, 2 to 4, 8 to 10.

Recorded Range:

Pliocene: San Diego Formation, Pacific Beach, California (!).

Pleistocene: Upper San Pedro Series, Long Wharf Canyon, Santa Monica, California (Chace, !); Los Cerritos Hill, Long Beach, California (Oldroyd, !); "Coal Mine", west side of Point Loma, San Diego County, California (!); Spanish Bight, San Diego, California (!).

Formation doubtful, Deadman Island, San Pedro, California (Chace, !).

Indian middens: San Nicolas Island, California (Lowe); mouth of Topanga Canyon, near Santa Monica, California (!); Redondo, California (!); La Jolla, California (!).

Living: Santa Barbara, California, to Magdalena Bay, Lower California; between tides.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Ant..	Pacific Beach, Cal.....	Mrs. Kate Stephens.....	S. Diego Soc.Nat.Hist.	[501]	San Diego.....	Pliocene
1	Int..	Pacific Beach, Cal.....	Mrs. Kate Stephens.....	S. Diego Soc.Nat.Hist.	[347]	San Diego.....	Pliocene
1	Int..	Pacific Beach, Cal.....	Mrs. Kate Stephens.....	Berry Coll. Cat. 3924.	[502]	San Diego.....	Pliocene
1	Post.	Pacific Beach, Cal.....	Mrs. Kate Stephens.....	S. Diego Soc.Nat.Hist.	[347]	San Diego.....	Pliocene
1	Post.	Pacific Beach, Cal.....	Mrs. Kate Stephens.....	S. Diego Soc.Nat.Hist.	[501]	San Diego.....	Pliocene
1	Ant..	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	Berry Coll. Cat. 3963.	[350]	Upper San Pedro...	Pleistocene
1	Post.	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	Berry Coll. Cat. 3963.	[493]	Upper San Pedro...	Pleistocene
1	Ant..	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	F. C. Clark Coll.....	[503]	Upper San Pedro...	Pleistocene
?1	Post.	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	F. C. Clark Coll.....	[504]	Upper San Pedro...	Pleistocene
1	Ant..	Los Cerritos Hill, Long Beach, Cal.....	T. S. Oldroyd.....	Dept. Geology, Stanford Univ.....	[660]	Upper San Pedro...	Pleistocene
1	Int..	Los Cerritos Hill, Long Beach, Cal.....	T. S. Oldroyd.....	Dept. Geology, Stanford Univ.....	[661]	Upper San Pedro...	Pleistocene
1	Post.	Los Cerritos Hill, Long Beach, Cal.....	T. S. Oldroyd.....	Dept. Geology, Stanford Univ.....	[662]	Upper San Pedro...	Pleistocene
1	Int..	Coal mine, W. side Pt. Loma, Cal.....	C. L. Hubbs.....	S. Diego Soc.Nat.Hist.	[498]	Upper San Pedro...	Pleistocene
1	Post.	Coal mine, W. side Pt. Loma, Cal.....	C. L. Hubbs.....	S. Diego Soc.Nat.Hist.	[498]	Upper San Pedro...	Pleistocene
1	Int..	Coal mine, W. side Pt. Loma, Cal.....	C. L. Hubbs.....	Berry Coll. Cat. 3923.	[499]	Upper San Pedro...	Pleistocene
1	Post.	Coal mine, W. side Pt. Loma, Cal.....	C. L. Hubbs.....	Berry Coll. Cat. 3923.	[500]	Upper San Pedro...	Pleistocene
1	Int..	Spanish Bight, San Diego, Cal.	Mrs. Kate Stephens.....	S. Diego Soc.Nat.Hist.	[348]	Upper San Pedro...	Pleistocene
2	Ant..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Berry Coll. Cat. 3973.	[688]	?	? Pleistocene
1	Ant..	? Deadman Id., San Pedro, Cal.....	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[670]	?"Upper San Pedro"	Pleistocene
1	Post.	Deadman Id., San Pedro, Cal.	E. P. Chace.....	Berry Coll. Cat. 3934.	[346]	?	Pleistocene

Remarks: In life this fine species is well distinguished from all its described relatives by the peculiarly bristling dorsal girdle scales, but, with fossils, reliance must be had upon the shell characters, which are more variable and perhaps not always so decisive, especially in light of the fact that many specimens are apt to be badly worn. Well preserved material, however, is usually very characteristic. The species agrees with *I. acrior* in its large size and strongly concave head valve, features in which both these species differ from *I. magdalenensis*, but it differs from both *acrior* and *magdalenensis* in the very weak, or in adults usually obsolete, sculpture of the central areas. The radial sculpturing of the terminal areas is also less well developed than in either of the other species. In fact, it is difficult at times to make out its presence at all. The lateral areas are usually rather like a weak copy of those of

acrior. The number of insertion teeth and slits seems to average rather less than in *acrior*. In the fossil specimens examined I find the number and arrangement of these to be generally as follows: i, 9-10 (one shell has 11; that figured from Santa Monica has 12); ii-vii, 2-2 (in one valve from Point Loma, 2-3); viii, 9 or sometimes 10 slits.

As a fossil *I. conspicuus* would appear to be much less abundant in most of the formations studied than its more tropical congener *I. acrior*.

Specimen 504, reported above with a query, may possibly be an *I. magdalenensis,* as on the central areas it shows distinct traces of a sculpture of the *magdalenensis* type, but other features point toward *conspicuus,* and in the absence of confirmatory material it seems best to leave it allocated as it is at present. It is a small specimen, with a diameter of only 9.2 mm.

24. Ischnochiton (Stenoplax) acrior Carpenter, 1892

(Plate IX; Plate X, figs. 1-3.)

1892. *Ischnochiton* (*Stenoplax*) *acrior* Carpenter, in Pilsbry, Man. Conch., (1), v. 14, p. 61, pl. 14, f. 86-89.

1917. *Ischnochiton acrior* Chace, Lorquinia, v. 2, p. 30 (recorded from Pleistocene of Santa Monica, Cal.).

Diagnosis: Valves quite heavy, large, depressed to moderately elevated, subcarinate, not beaked, all but the tail valve almost straight or weakly concave behind; lateral areas strongly elevated, these and the terminal areas sculptured by numerous strong, irregular, sharp, radiating riblets; central areas ornamented by numerous, acute, longitudinal, wrinkly, sometimes slightly anastomosing riblets; profile of head valve distinctly concave in front; tail valve large, flattened, with low mucro situated a little behind the center; sutural laminæ strong, deep, with a small notch at each side of the sinus; eaves wide, solid, massive, and strongly projecting past the stout, sharp teeth; slits 8, 2 to 4, 13.

Recorded Range:

Pleistocene: Upper San Pedro Series—Long Wharf Canyon, Santa Monica, California (Chace, !); "Coal Mine", west side of Point Loma, San Diego County, California (!).

Formation doubtful, Deadman Island, San Pedro, California (!).

Living: Cerros Island, Lower California, to Cape San Lucas, Lower California; between tides.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
2	Ant..	Loug Wharf Canyon, Santa Monica, Cal	F. C. Clark	F. C. Clark Coll	[351]	Upper San Pedro...	Pleistocene
8	Int..	Long Wharf Canyon, Santa Monica, Cal	F. C. Clark	F. C. Clark Coll	[351]	Upper San Pedro...	Pleistocene
2	Post.	Long Wharf Canyon, Santa Monica, Cal	F. C. Clark	F. C. Clark Coll	[351]	Upper San Pedro...	Pleistocene
1	Int..	Long Wharf Canyon, Santa Monica, Cal	F. C. Clark	Berry Coll. Cat. 3916	[344]	Upper San Pedro...	Pleistocene
1	Post.	Long Wharf Canyon, Santa Monica, Cal	F. C. Clark	Berry Coll. Cat. 3916	[352]	Upper San Pedro...	Pleistocene
1	Ant..	Coal mine, W. side Pt. Loma, Cal	C. L. Hubbs	Berry Coll. Cat. 3922	[495]	Upper San Pedro...	Pleistocene
1	Int..	Coal mine, W. side Pt. Loma, Cal	Mrs. Kate Stephens	Berry Coll. Cat. 3917	[343]	Upper San Pedro...	Pleistocene
1	Int..	Coal mine, W. side Pt. Loma, Cal	F. Stephens	S. Diego Soc.Nat.Hist.	[941]	Upper San Pedro...	Pleistocene
2	Int..	Coal mine, W. side Pt. Loma, Cal	C. L. Hubbs	S. Diego Soc.Nat.Hist.	[497]	Upper San Pedro...	Pleistocene
1	Post.	Coal mine, W. side Pt. Loma, Cal	C. L. Hubbs	S. Diego Soc.Nat.Hist.	[497c]	Upper San Pedro...	Pleistocene
?1	Post.	Coal mine, W. side Pt. Loma, Cal	C. L. Hubbs	S. Diego Soc.Nat.Hist.	[497d]	Upper San Pedro...	Pleistocene
1	Post.	Coal mine, W. side Pt. Loma, Cal	Mrs. Kate Stephens	S. Diego Soc.Nat.Hist.	[342]	Upper San Pedro...	Pleistocene
1	Post.	Coal mine, W. side Pt. Loma, Cal	C. L. Hubbs	Berry Coll. Cat. 3922	[496]	Upper San Pedro...	Pleistocene
3	Int..	Loc. 108, 2 mi. N. of Pt. Loma, Cal	Cal. Acad. Sci	Cal. Acad. Sci	[518]	Upper San Pedro...	Pleistocene
1	Int..	Loc. 108, 2 mi. N. of Pt. Loma, Cal	Cal. Acad. Sci	Berry Coll. Cat. 3931	[518]	Upper San Pedro...	Pleistocene
1	Post.	Loc. 108, 2 mi. N. of Pt. Loma, Cal	Cal. Acad. Sci	Cal. Acad. Sci	[518]	Upper San Pedro...	Pleistocene
1	Ant..	Deadman Id., San Pedro, Cal.	Arnold Coll	Dept. Geology, Stanford Univ	[685]	?	? Pleistocene
1	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll	Dept. Geology, Stanford Univ	[686]	?	? Pleistocene
1	Post.	Deadman Id., San Pedro. Cal.	Arnold Coll	Dept. Geology, Stanford Univ	[687]	?	? Pleistocene

Remarks: So far as the shell characters go this species is extremely close to *I. conspicuus,* differing principally in its strong, coarse sculpturing. It naturally follows that poor or badly eroded specimens are exceedingly difficult to separate when the two species occur together. The best preserved of the fossil specimens display considerable variation even within the specific limits, those from Point Loma being much flatter and showing a distinctly sparser, cruder sculpturing than those collected at Santa Monica by Dr. Clark, but the material is not sufficient to justify one in recognizing separate races for the

two localities. All the variations can be matched pretty well in a good series of recent specimens.

There is considerable variation in the number of insertion teeth. The Point Loma shells have slits as follows: valve i, 8; valves ii-vii, 4-3 and 3-3; valve viii, 10 to 13. Those from Santa Monica have: valve i, 10 to 11; valves ii-vii, 2-2 or 3-3; valve viii, 10. This variation is likewise paralleled in recent specimens.

The immense northern extension of the range of this species during late Pleistocene time through at least six degrees of latitude from its most northern living record is noteworthy. Rather oddly *I. acrior* appears almost always to accompany *I. conspicuus* in the fossil state, while, except for an unconfirmed note of the latter species from Magdalena Bay, among recent specimens such a coincidence has been recorded only at South Bay, Cedros Island, Lower California.[15] This leads one to wonder strongly whether a given species or genus may not be subject to change in its ability to adapt itself to specified climatic conditions through long periods of time, instead of such adaptation and consequent distribution in latitude being always the fixed criterion which some paleontologists seem to have assumed.

Pilsbry compares *acrior* more especially with *magdalenensis*, but if our northern *magdalenensis* are correctly so named, it seems to me that *I. conspicuus* is clearly the present species' nearest of kin.

Caliper measurements of the largest fossil valve seen [518a] are as follows: Maximum longitude 18.3, diameter 40, altitude 12 mm.

Subgenus Rhombochiton Berry, 1919

25. **Ischnochiton (Rhombochiton) regularis** (Carpenter, 1855)

1855. *Chiton regularis* Carpenter, Proc. Zool. Soc. London 1855, p. 232.

1864. *Lepidopleurus regularis* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, p. 554, 649.

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[15] H. N. Lowe,—Nautilus, v. 27, p. 28.

1879. *Ischnochiton regularis* Dall, Proc. U. S. Nat. Mus., v. 1, p. 296, pl. 2, f. 14 (radula).

1893. *Ischnochiton regularis* Pilsbry, Man. Conch., (1), v. 14, p. 142, pl. 18, f. 41-46.

1895. *Ischnochiton regularis* Ashley, Proc. Cal. Acad. Sci. (2), v. 5, p. 343 (recorded from Pliocene of San Pedro).

1903. *Ischnochiton regularis* Arnold, Mem. Cal. Acad. Sci., v. 3, p. 28, 42, 85, 342 (recorded from Pleistocene of San Pedro, Cal.).

1906. *Ischnochiton regularis* Arnold, Pectens of Calif., p. 35 (recorded from Pleistocene of San Pedro, Cal.).

1910. *Callistochiton regularis* Thiele, Rev. Syst. Chit., II, p. 112, 113.

1919. *Ischnochiton (Rhombochiton) regularis* Berry, Proc. Cal. Acad. Sci., (4), v. 9, p. 2.

Diagnosis[16]*:* Valves thin, elevated, carinate, not beaked; side slopes nearly straight; lateral areas only slightly raised, these and the terminal areas very delicately radially threaded; central areas with numerous, very fine and regular, microscopically granose riblets; mucro in front of middle of tail valve; insertion plates low and wide, connected across the sinus by a delicately toothed plate; teeth sharp; eaves solid; slits 14 to 16, 2-3, 22.

Recorded Range:

Pleistocene: Upper San Pedro Series—Lumber yard, San Pedro, California (Arnold).

Formation Doubtful—San Pedro, California (Ashley).

Living: Fort Bragg, California (!), to San Diego, California (Kelsey); between tides.

Remarks: Besides the old record of Ashley, this species has been reported from the type locality of the Upper San Pedro Series at San Pedro by Arnold, but I have been unsuccessful

[16] Description drawn from recent specimens.

in all attempts to locate his specimens, and no fossil material of the species is in any of the collections seen by me. From its present range it is a species which one would expect to find in the Lower San Pedro horizons rather than the Upper. Its occurrence in the latter therefore needs confirmation. Arnold did not figure his specimens.

Subgenus **Lepidozona** Pilsbry, 1892

26. **Ischnochiton (Lepidozona) pectinulatus** Carpenter, 1893*

(Plate X, figs. 4-6.)

1864. *Lepidopleurus pectinatus* Carpenter, Rep. Brit. Assoc. Adv. Sci., 1863, p. 649 (not *Chiton pectinatus* Sowerby, 1840).

1865. *Ischnochiton* (*Lepidopleurus*) *pectinatus* Carpenter, Proc. Cal. Acad. Nat. Sci., (1), v. 3, p. 211.

1892. *Ischnochiton* (*Ischnochiton*) *clathratus* Pilsbry, Man. Conch., (1), v. 14, p. 128 (pars), pl. 26, f. 31-34.

1893. *Lepidopleurus pectinulatus* Carpenter, in Pilsbry, Man. Conch., (1), v. 14, p. 129.

Diagnosis[17]*:* Valves thin, low, carinate; side slopes weakly arcuate; lateral areas elevated, bearing 5-7 closely granose, sometimes bifurcating, radial riblets, the posterior rib lower, but coarser, its tooth-like tubercles projected backward, strongly pectinating the suture; head valve similarly sculptured, the ribs 25-35 in number; sculpture of posterior area of tail valve likewise similar but a little weaker; central areas closely and sharply sculptured with 15-19 longitudinal ribs on each side, nearly straight everywhere except on the jugum of the second valve where they strongly diverge, intersected by numerous rather coarser but less sharp transverse bars, the intersections nodular, interstices deeply pitted; mucro of tail valve low, scarcely projecting, nearly median; sutural laminæ low, arcuate, connected by a dentate plate across the sinus; teeth short and stout; slits 11 to 12, 1-1, 14 to 16.

*This is *Ischnochiton clathratus* of many writers on west American chitons, but not, I believe, of Reeve 1847, nor of Chace (:17, p. 30, = *I. sanctæmonicæ* Berry).

[17] Description drawn in part from recent specimens.

Recorded Range:

Pleistocene: Upper San Pedro Series, Long Wharf Canyon, Santa Monica, California (?!); Spanish Bight, San Diego, California (!).

Living: Monterey, California (!), to Todos Santos Bay, Lower California (!).

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
?2	Int..	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	F. C. Clark Coll.....	[508]	Upper San Pedro...	Pleistocene
?1	Int'..	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark	Berry Coll, Cat. 3979.	[508]	Upper San Pedro...	Pleistocene
1	ii	Spanish Bight, San Diego, Cal.....	Mrs. Kate Stephens.....	Berry Coll. Cat. 3925.	[507]	Upper San Pedro...	Pleistocene

Remarks: I. pectinulatus is a characteristic representative of a numerous and difficult group of *Ischnochitonidæ,* which, according to our present information, attains by far its most remarkable development on the northwest coast of America. Among this melange of species, but few of which have as yet been discovered in the fossil state, *I. pectinulatus* is recognizable chiefly by minor details of sculpturing, notably the divarication of the lateral and terminal areas into distinct, strongly irregularly multi-granose riblets (generally 5-6 in number on the lateral areas), while a series of especially strong backwardly directed tubercles (12-18 on a side) dentates the posterior margin of all the valves but the last. There are 15-19 longitudinal riblets on each side of the central region, overlying a transverse grating rather stronger than usual. The riblets of the jugal region diverge strongly on the second valve, but only weakly or not at all on the succeeding valves, very unlike the condition seen in the related *cooperi* and *mertensii.*

The above notes, as well as the identification of the fossil specimens, are based upon recent specimens from the San Diego region.

27. Ischnochiton (Lepidozona) cooperi Carpenter, 1879

(Plate XI.)

1879. *Ischnochiton cooperi* Carpenter, in Dall, Proc. U. S. Nat. Mus., v. 1, p. 296, pl. 2, f. 15 (radula).

1892. *Ischnochiton* (*Ischnochiton*) *cooperi* Pilsbry, Man. Conch., (1), v. 14, p. 127, pl. 26, f. 27-30.

1919. *Ischnochiton cooperi* Chace and Chace, Lorquinia, v. 2, p. 43 [3] (recorded from Pleistocene of Pt. Fermin, Cal.).

Diagnosis: Valves moderately thin, strongly elevated, sharply carinate; side slopes straight or but weakly arcuate; lateral areas elevated, with 5-6 low radial flutings, each bearing a series of usually elongate, often abraded pustules, the posteriormost coarser and projecting backward so as to pectinate the sutural margin; head valve similarly sculptured, the ribs 20-30 in number, their interspaces distinctly fluted out and concentrically decussated by the lines of growth; posterior area of tail valve similar but with the lines of pustules rather less definitely arranged; central areas sculptured by about 20 very sharply cut, longitudinal ribs, straight at the sides but distinctly diverging on the jugal tracts of all the valves, especially the second, their interspaces decussated by numerous, very closely placed, transverse riblets of much less prominence; mucro of tail valve low, scarcely projecting, nearly median; sutural laminæ low, wide, connected across the shallow sinus by a dentate plate; teeth short, not projecting; eaves solid; slits 8 to 11, 1-1, 9 to 11, with distinct pore lines leading into them.

Recorded Range:

Pleistocene: Lower San Pedro Series—Chiton Bed, Point Fermin, California (Chace and Chace, !); near lighthouse, Point Fermin, California (!); Nob Hill Cut, San Pedro, California (!); "Crawfish George's", San Pedro, California (!).

Formation doubtful—Deadman Island, San Pedro, California (!).

Living: Coos Bay, Oregon (!), to Anacapa Islands, Santa Barbara Group, California (Yates).

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Berry Coll. Cat. 4043.	[949]	Lower San Pedro...	Pleistocene
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. & E. M. Chace, 1918	Chace Coll.....	[1029]	Lower San Pedro...	Pleistocene
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Chace Coll.....	[1415]	Lower San Pedro...	Pleistocene
1	Ant..	Near lighthouse, Pt. Fermin, Cal.....	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4112.	[1105]	Lower San Pedro...	Pleistocene
4	Int..	Near lighthouse, Pt. Fermin Cal.....	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4112 / Cal. Acd. Sci.....	[1106]	Lower San Pedro...	Pleistocene
3	Int..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[651]	Lower San Pedro...	Pleistocene
?1	Ant..	Crawfish George's, San Pedro, Cal.....	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4047.	[955]	Lower San Pedro...	Pleistocene
3	Int..	Crawfish George's, San Pedro, Cal.....	E. P. & E. M. Chace, 1918	Berry Coll. Cat. 4047.	[956]	Lower San Pedro...	Pleistocene
1	Int..	? Deadman Id., San Pedro, Cal.....	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[669]	?"Upper San Pedro"	Pleistocene
?1	Int..	? Deadman Id., San Pedro, Cal.....	Oldroyd Coll.....	Berry Coll. Cat. 5184.	[648]	?"Upper San Pedro"	Pleistocene
1	Ant..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[708]	?	? Pleistocene
1	Ant..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept Geology, Stanford Univ.....	[722]	?	? Pleistocene
4	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[723]	?	? Pleistocene
2	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[724]	?	? Pleistocene
1	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[730]	?	? Pleistocene

Remarks: This common central and northern California species appears to be of rather frequent occurrence in the Pleistocene around San Pedro, being probably characteristic of the Lower San Pedro Series. Whereas in the recent state it is much less common as a rule than its associate, *I. mertensii,* the reverse is true of the fossils.

I. mertensii is the only species with which it is likely to be confounded. In the case of valves ii-vii, however, even very fragmentary specimens are readily identifiable by the extremely numerous, crowded, transverse bars connecting the longitudinal riblets of the central areas, making their interspaces appear finely, but distinctly striate to the unaided eye. The lines of growth give a similar, but coarser effect of striation to the interspaces between the lines of more or less coalescent pustules on the head valve, so that this too has a certain individuality of aspect very helpful in distinguishing it from the corresponding valve in *mertensii.*

28. **Ischnochiton (Lepidozona) mertensii** (Middendorff, 1846)

(Plate X, figs. 7-12.)

1846. *Chiton Mertensii* Middendorff, Bull. Acad. Sci. St. Petersb., VI, p. 118 (fide Pilsbry).

1847. *Chiton (Phoenochiton, Hamachiton, Stenosemus) Mertensii* Middendorff, Malac. Ross., p. 34, 125, pl. 14, f. 1-3.

1879. *Lepidopleurus Mertensii* Dall, Proc. U. S. Nat. Mus., v. 1, pp. 297, 332, pl. 2, f. 18-18a (radula).

1892. *Ischnochiton (Ischnochiton) mertensii* Pilsbry, Man. Conch., (1), v. 14, p. 125, pl. 26, f. 20-26.

Diagnosis[18]: Valves moderately thin, fairly elevated, carinate; side slopes straight or but weakly arcuate; lateral areas elevated, divided by shallow, narrow grooves into 5 or 6 low, often obscure, flattened, radial ribs, each bearing a series (sometimes bifurcating) of rounded or pyriform pustules, the posteriormost series directed obliquely backward so as to dentate the suture; head valve similarly sculptured, the ribs and grooves perhaps 25 in number; posterior area of tail valve similar; central areas sculptured by 12-15 sharply cut longitudinal bars, subparallel on the pleural regions but usually distinctly divergent on the jugal tracts, especially on valve ii, their interspaces, except as a rule on the jugum, decussated by numerous radially arcuate, transverse riblets of much less prominence; mucro of tail valve low, median; sutural plates low, wide, connected across the sinus by a dentate plate; teeth short, not projecting; eaves solid; slits 10 to 11, 1-1, 10 to 12.

Recorded Range:

Pleistocene (?): Formation doubtful—Deadman Island, San Pedro, California (!).

Living: Sitka, Alaska (Dall), to San Martin Island, Lower California (Baker); between tides to 50 fathoms.

[18] Description drawn in part from recent specimens.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
?1	Ant..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.	[707]	?	? Pleistocene
4	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.	[709]	?	? Pleistocene
1	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.	[725]	?	? Pleistocene
2	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.	[710]	?	? Pleistocene

Remarks: It is not without a little hesitation that I refer all the specimens catalogued above to *I. mertensii,* as few of them are sufficiently well preserved to be characteristic in all particulars. Several of them, e. g. 725, I think are almost certainly this species, but the others are more doubtful. It may be that there is another species represented in the lot, but if so I do not think it can be one of the known recent species.

So far as shell characters go, the special features of *mertensii* are the numerous, usually distinctly separate, rounded or pear-shaped pustules of the terminal and lateral areas, the relative coarseness of the latticing between the longitudinal ribs of the central areas, and the fact that these ribs usually diverge strongly on the jugal tract of all the valves, except of course the head valve, their interspaces in this region being smooth as a rule, or with only weak traces of the interlatticing.

Although recorded from as far south as Lower California, this species cannot be said to be a common one much below Monterey County, and its presence in any numbers in any horizon to that extent would therefore indicate northern affinities. In southern California at the present time its place between tides is everywhere taken by *I. pectinulatus, mertensii* here being an off-shore species.

29. Ischnochiton (Lepidozona) cf. sinudentatus Carpenter, 1892

(Plate XII, figs. 10-17)

?1892. *Ischnochiton* (*Ischnochiton*) *sinudentatus* Carpenter, in Pilsbry, Man. Conch., (1), v. 14, p. 128.

Recorded Range:

Pleistocene: Formation doubtful—Deadman Island, San Pedro, California (!).

Living: Monterey and Pacific Grove, California (!).

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	? Deadman Id., San Pedro, Cal.....	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[668]	?"Upper San Pedro"	Pleistocene
1	Ant..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[704]	?	? Pleistocene
1	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[705]	?	? Pleistocene
1	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll	Berry Coll. Cat. 4573.	[705]	?	? Pleistocene
1	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[706]	?	? Pleistocene

Remarks: Several valves in the Arnold and Oldroyd collections appear to represent a small species of *Lepidozona* which evidently belongs to the puzzling *sinudentatus*-group, several members of which have been described or named from the vicinity of Monterey. Perhaps the chief reason this group is more troublesome than most is that it is very insufficiently known. Neither *sinudentatus* itself, not the apparently allied *decipiens* Carpenter and *berryi* Dall have been any too adequately described, and no figures appear to be extant of any of these species. The fossil specimens show traces of a toothed plate across the sinus as described for *sinudentatus,* while they further agree very fairly with certain recent specimens from Pacific grove which I tentatively refer to Carpenter's species. The figures here given should serve to fix the identity of the present form, in case *sinudentatus* proves to be a different thing.

From other North American members of the *Lepidozona*-group, whether recent or fossil, this species is easily separable by reason of its small size, elevated outline, sharp dorsal ridge, distinctly convex slopes (though the height and convexity vary more or less in accordance with the serial position of the valves), numerous low, weakly granose, radial ribs of the terminal areas, 3 to 6 similarly granose ribs on the lateral areas, and the 12 to 15 strongly interlatticed, longitudinal ribs on each side of the central area, these last being considerably finer and closer in the jugal region.

30. Ischnochiton (Lepidozona) sanctæmonicæ Berry, new species

(Plate XII, figs. 1-9.)

1917. *Ischnochiton clathratus* Chace, Lorquinia, v. 2, p. 30. *not Chiton clathratus* Reeve 1847 (recorded from Pleistocene of Santa Monica, Cal.).

Diagnosis: Valves small, thin, elevated, carinate; side slopes nearly straight; lateral areas elevated, divided into 4-5 low, distinct, radial ribs, with narrower, coarsely granular interspaces, the sutural margin weakly dentate; head valve similarly sculptured, the ribs 32-47 in number; posterior area of tail valve similarly sculptured with about 25 ribs, obsolete toward the mucro; central areas on each side with 25-28, fine, more or less nodulose, longitudinal riblets, with abrupt, rather wider, deeply channeled interspaces, decussated by coarse, transverse threadings nearly as strong as the longitudinal ribs; mucro of tail valve low, median; sutural laminæ low, wide, connected across the shallow sinus by a short toothed plate; teeth stout, somewhat projecting; eaves rough but not truly spongy; slits 11, 1-1, 10, with conspicuous pore lines leading into them.

Type: An intermediate valve [883] entered as Cat. No. 3992 of the author's collection. A paratype is deposited in the collection of the California Academy of Sciences and there is one in the private collection of Dr. F. C. Clark.

Type Locality: Upper San Pedro Pleistocene of Long Wharf Canyon, Santa Monica, California; Dr. F. C. Clark; 3 head, 9 median, 1 tail valves.

Range: Unknown except type locality as given above.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Remarks	Formation	Period
1	Ant..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark..	Berry Coll. Cat. 3993.	[881]	Paratype	Upper San Pedro.	Pleistocene
2	Ant..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark..	F. C. Clark Coll.	[882]		Upper San Pedro.	Pleistocene
1	Int..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark..	Berry Coll. Cat. 3992.	[883]	Type.	Upper San Pedro.	Pleistocene
1	Int..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark..	Cal. Acad. Sci.	[884]	Paratype	Upper San Pedro.	Pleistocene
7	Int..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark..	F. C. Clark Coll.	[885]		Upper San Pedro.	Pleistocene
1	Post.	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark..	Berry Coll. Cat. 3993.	[886]	Paratype	Upper San Pedro.	Pleistocene

Description: Head valve moderate in height, crescentic, ornamented above by about 32-47 strong, rounded or slightly flattened, radiating ribs, more numerous toward the margin, occasionally bifurcating, but for the most part simple and slightly wider than their finely, distinctly, closely granulated interspaces. Posterior margins further decorated by a series of about 10 short, strong, crescentic ridges, lying somewhat obliquely transverse of the radii. Interior with a low, irregular, transverse callus. Slits 11, each connected with the apex of the valve by a conspicuous series of transverse, slit-like pores. Teeth sharp, strongly beveled, scarcely longer than the solid, somewhat overhanging, crenulated eaves.

Median valves comparatively short and wide, strongly elevated, with a fairly sharp dorsal ridge and comparatively straight side slopes; not beaked. Lateral areas sharply defined, moderately elevated, sculptured much as above described for the head valve, the 4-5 radial ribs separated by rather narrower granular interspaces, and the posterior margin rendered weakly dentate by a series of perhaps a dozen crescentic tubercles placed obliquely transversely to the marginal radius. Jugal tract not well defined. Entire central area sculptured by numerous (in largest specimens about 25-28 on a side), fine, usually nearly straight, often nodulose, longitudinal riblets, appearing not quite so wide as their abrupt, deeply cut interspaces, and connected across the latter by rather coarse concentric threadings corresponding in their course somewhat to the lines of growth and on a lower level than the longitudinal riblets. Jugal region with the longitudinal bars still parallel, but with the transverse sculpture weaker than on the slopes. Interior with a strong, transverse, obtusely V-shaped callus. Sutural laminæ evenly arcuate, short and broad, connected across the shallow sinus by a short, toothed plate, which, when perfect, may project past the tegmentum; 5-6 more or less irregular, sometimes ill-defined, series of transverse, slit-like pores apparently corresponding in position to the slits in this plate. Insertion teeth scarcely beveled and more projecting than those of the head valve. Slits 1-1, a conspicuous radial series of the transverse, slit-like pores running to their apices. Eaves overhanging.

Tail valve with low, subcentral mucro. Posterior area elevated toward the sides in front, slightly concave behind the

mucro; sculptured by about 25 low, radiating ribs, obsolete toward the mucro. Central area sculptured in similar fashion to the corresponding region on the median valves, the longitudinal riblets about 15 on a side. Interior with a triangular, strongly dendritic callus, its central portion showing about 4 irregular, longitudinal rows of the transverse pores leading into the short, weakly toothed plate connecting the sutural laminæ across the shallow sinus. Teeth similar to those of head valve, but much shorter, and fitting in under the eaves more closely. Slits 10, each the marginal terminus of the usual radiating series of transverse, slit-like pores.

Caliper measurements of the type and paratypes are as follows:

	Head valve	Med. valve	Med. valve	Tail valve
		Type		
	[881]	[883]	[884]	[886]
Length	3.5 mm.	2.8 mm.	2.6 mm.	2.7 mm.
Diameter	6.8	7.7	7.7	4.7
Height	2.0	3.4	3.5	1.5

Remarks: In the case of this species comparison is chiefly needed with *I. pectinulatus*, *I. sinudentatus*, and perhaps *I. decipiens*, although in the last instance the insufficiency of the original description, as well as the rarity of authentic specimens, precludes any positive opinion. From both the other species *I. sanctæmonicæ* differs in the much more numerous longitudinal riblets of the central areas. From *I. pectinulatus* it further differs in its much smaller size, the lack of prominent pustules on the ribs of the lateral and terminal areas, and the altogether more delicate scheme of sculpturing.

It is a very pretty little species occurring not rarely in the type horizon.

31. Ischnochiton (Lepidozona), species

A nearly perfect anterior valve collected in the Upper San Pedro Pleistocene of Los Cerritos Hill, Long Beach, California, by T. S. Oldroyd [664], does not seem to be referable to any of the foregoing or other described species. It is apparently quite close to *I. sanctæmonicæ*, but differs from it in its greater elevation, steeper front slope, much narrower ribs, and pecu-

liarly fluted-out interspaces between the latter. On the basis of such insufficient material, however, it is doubtfully advisable to erect a new species.

Subfamily Callistochitoninæ Berry, new subfamily

Genus **Callistochiton** Carpenter, 1882

32. **Callistochiton decoratus punctocostatus** Pilsbry, 1896

(Plate XIV, figs. 1-6)

1893. *Callistochiton decoratus* Pilsbry, Man. Conch., (1), v. 15, p. 87, p. 16, f. 54 (not of Carpenter, 1893).

1896. *Callistochiton decoratus* var. *punctocostatus* Pilsbry, Nautilus, v. 10, p. 50.

1919. *Callistochiton decoratus* Chace and Chace, Lorquinia, v. 2, p. 42 [2] (recorded from Pleistocene of Pt. Fermin, Cal.).

Diagnosis: Valves of moderate thickness, rather depressed, but carinate; side slopes distinctly arcuate; lateral areas raised, strongly radially bicostate with the central sulcus decussated, the ribs at first tubercular and subcarinate, later smoother and often developing a secondary sulcus on the ridge or even bifurcating; head valve with 11, posterior area of tail valve with 9 similar ribs, their interspaces concentrically decussated; central areas in adult with perhaps 10-15 longitudinal ribs, nearly equal in width to the interspaces, across which they are connected by arcuately-transverse radial threading, the uppermost sculpture usually entirely lost on the jugum, which then shows a triangular smooth area of varying extent; mucro of tail valve low, distinctly postmedian, the posterior slope gradual at first, then suddenly steep; sutural plates low, arcuate, connected across the squarish sinus by a delicately toothed plate; teeth curved, sharp and distinct, not projecting; eaves thin, solid, overhanging; slits 9 to 11, 1-1, 9 to 12, with distinct pore lines leading into them.

Recorded Range:

Pleistocene: Lower San Pedro Series—Chiton Bed, Point Fermin, California (Chace and Chace, !).

Formation doubtful—Deadman Island, San Pedro, California (!).

Living: Monterey, California (Williamson), to San Diego, California (!).

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Berry Coll. Cat. 4044.	[950]	Lower San Pedro...	Pleistocene
4	Ant..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[728]	?	? Pleistocene
1	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[729]	?	? Pleistocene
7	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[715]	?	? Pleistocene
1	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Berry Coll. Cat. 4574	[715]	?	? Pleistocene

Remarks: I am not sure what value should be put upon the form here ranked as a subspecies of Carpenter's *decoratus,* but if it be valid at all, I believe practically all the *decoratus* now found living in the waters of California proper must be referred to it. Recent specimens show great variation in all details of shape and sculpture, particularly in the very feature upon which *punctocostatus* was principally founded in the first place, namely, the extent to which the typical smooth area on the jugum may be invaded by the sculpture of the pleural areas. The typical *decoratus* from Lower California is said to have a conspicuous, wide, rather sharply defined, triangular, smooth area on the jugum of valves ii to viii. This feature is wanting in typical *punctocostatus,* which is "somewhat irregularly pitted toward the beaks, and with rows of pits on each side of a small oblong smooth tract at the ridge; most valves pitted also on the ridge anteriorly" [19]. Even *punctocostatus* as thus described does not represent the extreme found in the form I here describe as *C. d. ferminicus,* where the sculpturing is developed clear across the valves. As a matter of fact one finds all transitions in the direction of typical *decoratus.* I have yet to see two specimens with sculpture exactly similar in this respect.

The Deadman Island specimens, curiously enough, include no median valves, but the tail valves show only a very narrow, rib-like, smooth area on the jugum, or the sculpture may extend clear across, though becoming more or less obsolete as the center is reached. The number of radial ribs in this series of valves is uniformly 9, of longitudinal riblets 10 to 15 on a side, and of slits, 9 to 11. The specimen illustrated (Pl. XIV, fig. 4) has the following caliper measurements: Length 3.7, diameter 6.5, height 2.3 mm.

[19]Pilsbry, H. A.—Nautilus, v. 10, p. 50, 1896.

One would expect the shell from Point Fermin to be an immature *ferminicus*, but it is so different from its associated specimens and so similar to recent shells that I refer it here.

From the associated members of the genus this species as a whole is remarkably distinct. The less highly modified insertion teeth, the 11 more or less carinated ribs of the head valve, the 9 similar ribs of the tail valve, and the delicate ribbing of the central areas are among the more easily available distinguishing features.

33. **Callistochiton decoratus ferminicus** Berry, new subspecies

(Plate XIV, figs. 7-8.)

Diagnosis: Similar to the preceding subspecies, but larger, much more elevated, with more strongly arcuate side slopes; sculpture of the central areas continuous over the jugum without the interposition of a smooth area, the longitudinal riblets very fine and numerous, 20-24 on a side.

Type: An intermediate valve [1040] entered as Cat. No. 4571 of the author's collection. A paratype is Cat. No. 4572 [1095].

Type Locality: Chiton Bed, Lower San Pedro Pleistocene, Point Fermin, California; E. P. and E. M. Chace, 1918; two median valves.

Description: (See diagnosis above.)

Material Examined: No specimens other than the type, paratype, and another specimen taken from the same exposure by Chace and Berry in 1920 have been seen.

Remarks: The *Callistochiton decoratus* complex is so extraordinarily variable for a chiton, it is only with diffidence that one adds a new name to the already overburdened list. Nevertheless the differences among three of the fossil valves from Point Fermin and all other fossil or recent specimens I have seen are too patent to go without recognition. None of a very extensive series of recent specimens before me approaches *ferminicus* either in fineness of sculpture of the central areas, in elevation, or in size.

Although otherwise in fair condition, the type is too worn within to show the characters of the articulamentum, and unfortunately the paratype is rather badly broken.

The dimensions of the type are: Length, 4.+; diameter, 9.8; height 4.6 mm.

34. **Callistochiton crassicostatus** Pilsbry, 1893

(Plate XIII.)

1893. *Callistochiton crassicostatus* Pilsbry, Man. Conch., (1), v. 14, p. 264, pl. 58, f. 1-6.

1917. *Callistochiton crassicostatus* Chace, Lorquinia, v. 2, p. 30 (recorded from Pleistocene of Santa Monica, Cal.).

1919. *Callistochiton crassicostatus* Chace and Chace, Lorquinia, v. 2, p. 42 [2] (recorded from Pleistocene of Pt. Fermin, Cal.).

(——. *Chiton fimbriatus* of various authors, but not of Sowerby, teste Pilsbry.)

Diagnosis: Valves small, thick, massive, well arched, scarcely angled; side slopes strongly arcuate; lateral areas raised into a strong, thickened rib, coarsely granulated and cut by one or more shallow radial sulci; head valve typically with 7 massive, radial ribs, each with a shallow median sulcus and sometimes others toward the base, the interspaces concentrically decussated; central areas strongly longitudinally ribbed, 7-12 ribs

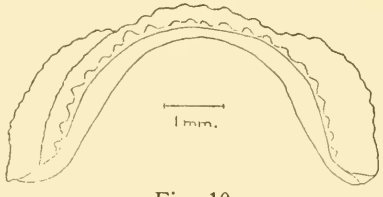

Fig. 10

Fig. 10. *Callistochiton crassicostatus* Pilsbry. Anterior elevation of valve illustrated in Plate XIII, figs. 6-7.

on a side, distinctly converging on the jugum, the interspaces finely latticed across; tail valve elevated, flattened above, the mucro increasingly posterior with growth, the slope behind it becoming almost vertical; sutural plates low, distinctly connected across the shallow sinus: teeth short, scarcely projecting in valves i-vii, very short and thick in valve viii; eaves solid; slits 9, 1-1, 14 to 18.

Recorded Range:

Pleistocene: Lower San Pedro Series — Chiton Bed, Point Fermin, California (Chace and Chace, !); Nob Hill Cut, San Pedro, California (!).

Upper San Pedro Series—Long Wharf Canyon, Santa Monica, California (Chace, !); "Coal mine", west side of Point Loma, California (!).

Formation doubtful—Deadman Island, San Pedro, California (!).

Living: Monterey, California (!), to Cedros Island, Lower California (Lowe); shore to 15 fathoms.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Chace Coll.....	[951]	Lower San Pedro...	Pleistocene
2	Ant..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Berry Coll. Cat. 4045.	[1091]	Lower San Pedro...	Pleistocene
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Berry Coll. Cat. 4045.	[1024]	Lower San Pedro...	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Cal. Acd. Sci.....	[1094]	Lower San Pedro...	Pleistocene
2	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1918.....	Chace Coll.....	[1093]	Lower San Pedro...	Pleistocene
1	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1919.....	Berry Coll. Cat. 4045.	[1185]	Lower San Pedro...	Pleistocene
2	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace, 1920.....	Chace Coll.....	[1360]	Lower San Pedro...	Pleistocene
4	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Berry Coll. Cat. 4967.	[1417]	Lower San Pedro...	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Berry Coll. Cat. 4967.	[1417]	Lower San Pedro...	Pleistocene
5	Int..	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Chace Coll.....	[1418]	Lower San Pedro...	Pleistocene
1	Post.	Chiton Bed, Pt. Fermin, Cal.	E. P. Chace & S. S. Berry, 1920.....	Chace Coll.....	[1418]	Lower San Pedro...	Pleistocene
4	Ant..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[645]	Lower San Pedro...	Pleistocene
5	Int..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[646]	Lower San Pedro...	Pleistocene
3	Post.	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[647]	Lower San Pedro...	Pleistocene
1	Ant..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Berry Coll. Cat. 3970.	[645]	Lower San Pedro...	Pleistocene
1	Int..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Berry Coll. Cat. 3970.	[646]	Lower San Pedro...	Pleistocene
1	Post.	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.....	Berry Coll. Cat. 3970.	[647]	Lower San Pedro...	Pleistocene
1	Ant..	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	Berry Coll. Cat. 3927.	[509]	Upper San Pedro...	Pleistocene
7	Ant..	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	Berry Coll. Cat. 3928.	[511]	Upper San Pedro...	Pleistocene
28	Ant..	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	F. C. Clark Coll.....	[510]	Upper San Pedro...	Pleistocene
19	Int..	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	F. C. Clark Coll.....	[514]	Upper San Pedro...	Pleistocene
1	Int..	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	Berry Coll. Cat. 3927.	[512]	Upper San Pedro...	Pleistocene
3	Int..	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	Berry Coll. Cat. 3928.	[513]	Upper San Pedro...	Pleistocene
3	Post.	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	Berry Coll. Cat. 3927.	[515]	Upper San Pedro...	Pleistocene
9	Post.	Long Wharf Canyon, Santa Monica, Cal.....	F. C. Clark.....	F. C. Clark Coll.....	[516]	Upper San Pedro...	Pleistocene
1	Ant..	Coal mine, W. side Pt. Loma, Cal.....	Mrs. Kate Stephens.....	Berry Coll. Cat. 3926.	[349]	Upper San Pedro...	Pleistocene
1	Ant..	Coal mine, W. side Pt. Loma, Cal.....	C. L. Hubbs.....	S. Diego Soc. Nat. Hist.	[492]	Upper San Pedro...	Pleistocene
4	Ant..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[712]	?	? Pleistocene
1	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[713]	?	? Pleistocene
7	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[679]	?	? Pleistocene
1	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[682]	?	? Pleistocene
7	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[714]	?	? Pleistocene
1	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.....	Dept. Geology, Stanford Univ.....	[680]	?	? Pleistocene
1	Post.	? Deadman Id., San Pedro, Cal.....	Oldroyd Coll.....	Dept. Geology, Stanford Univ.....	[666]	?"Upper San Pedro"	Pleistocene

Remarks: Occasional unmistakable specimens of this peculiar species have been discovered in the Pleistocene of many localities, and in the Long Wharf Canyon deposit it is one of the commonest forms to be found, being there exceeded in abundance only by the nearly related *C. palmulatus mirabilis* Pilsbry. This seems the more strange, since nowhere along our coast at the present time can it be said that *crassicostatus* is found in any very appreciable numbers. Usually but an occasional specimen or two is taken even at extreme low tides. Along the entire coast of southern California the commonest present-day *Callistochiton* is by all odds *C. decoratus punctocostatus*, a species for from common as a fossil.

Although very distinct in the living condition, poorly preserved fossils of *crassicostatus* are sometimes hard to identify on account of the possibility of their being mixed with *C. palmulatus mirabilis.* Well preserved valves, on the other hand, are as readily separable as recent specimens. This is quickly seen when the chief diagnostic characters of the two forms are placed in parallel columns:

HEAD VALVE

crassicostatus	*mirabilis*
Primarily with *7* heavy, irregularly tubercular ribs, each divided almost at once by a median sulcus, and in old shells with a secondary sulcus on each side toward the base.	Primarily with *9* moderately heavy, strongly tubercular ribs, each sooner or later showing in the adult a median sulcus; the posterior rib on each side apparently duplex.
Slits typically 9 in number, *2 on each side of the central slit being adnate.*	Slits typically 9 in number, *regularly spaced.*

MEDIAN VALVES

Lateral areas elevated into a typically[20] *single, very heavy,* crudely nodulose rib, with usually about 4 rather weak, radiating furrows.	Lateral areas *divided by a strong median furrow* into two nodulose ribs, each of which may bear a weak secondary furrow.
Central areas with *7-12* quite strong, interlatticed ribs on a side, *showing a distinct tendency to converge anteriorly on the ridge,* even on valve ii.	Central areas with *14-18* (fewer in very small specimens) moderately strongly interlatticed ribs on a side, *not* showing any well-marked tendency to converge in front, and strongly divergent on valve ii.

[20] One fossil specimen [682], which seems otherwise thoroughly referable to *crassicostatus,* shows sharply duplex lateral ribs recalling those of *palmulatus* and *mirabilis.*

TAIL VALVE

Flattened above.
Mucro strongly posterior (less so in juvenile specimens). Posterior area with 5-6 heavy ribs, at first simple, but developing from 1 to 4 grooves toward the base.

Slits *14-18.*
Longitudinal ribs of central areas 5-8 on a side.

Mucro strongly anterior, the large posterior area usually *immensely thickened and elevated behind the mucro;* ribs 5-7, heavy, and though at first simple, soon developing a strong median furrow, with sometimes 1 or 2 secondary furrows toward the base.
Slits *18-25.*
Longitudinal ribs of central areas 7-9 on a side.

The marginal toothing in the anterior valve of this species is peculiar and apparently characteristic, the remarkable feature being that certain of the teeth are excessively minute due to the close approximation in pairs of the slits which bound them, a pair of slits in such cases being brought into coincidence with one of the external ribs instead of the usual single slit. The typical arrangement, where the duplication affects only the slits lying immediately on each side of the central one is clearly shown in Pilsbry's figure in the "Manual" (op. cit., pl. 58, fig. 4), but this has not become so fixed but that it is subject to some strangely irregular variation.[21] The gross number of slits is ordinarily 9, but even this is subject to modification. Reducing the number and arrangement of the slits with respect to the ribs to a formula, 17 Santa Monica specimens examined yield the following figures:

Arrangement symmetrical—

11 show the formula	1-1-2-1-2-1-1,	total 9 slits
2 " " "	1-1-2-2-2-1-1,	" 10 "
1 shows " "	1-1-1-1-1-1-1,	" 7 "

Arrangement asymmetrical—

2 show the formula	1-1-2-1-2-2-1,	total 10 slits
1 shows " "	1-2-1-1-1-1-1,	" 8 "
1 " " "	1-2-2-2-2-1-1,	" 11 "

With one single exception (which is 8-ribbed), all the above specimens have 7 strong primary ribs, simple at their origin, but soon developing a median sulcus and eventually in well grown specimens showing a very constant tendency to the formation of an accessory sulcus on each side of the primary one toward the base.

[21] Of course it is possible that if a sufficiently large series of specimens could be examined, the variations would not appear so irregular.

Of the intermediate valves examined from the same material, 2 show 12 longitudinal riblets on each side of the central areas, 3 show 11 (or 10-11), 3 show 10 (or 9-10), 3 show 9 (or 8-9), 2 show 8 (or 7-8), and 1 shows 7.

On the tail valves the riblets of the central areas are fewer: 6 on a side (or 5-1-5) in 6, 7-1-7 in 1, 8-1-8 in 1, 6-1-6 in 1, and 5 on a side in 1 specimen. 8 of these same valves show 5 strong radial ribs each, the other 3 shells having 6 each. 2 have 18 slits, 4 have 16, 3 have 15, and 1 has 14. No relation is evident between a maximum number of ribs and an increased quota of slits. Toward the base the ribs become double, and in larger shells triple, quadruple, or (in the case of the outermost pair) even quintuple at the base in similar fashion to the radial ribs of the other valves.

The specimens from the Lower San Pedro Formation at Nob Hill run rather larger than those from Santa Monica, and have unusually sharp, clear sculpture and teeth. Among these have been noted 7 head valves with the typical slit formula 1-1-2-1-2-1-1, none being certainly atypical. Of the median valves, 5 show longitudinal riblets on the central areas as follows: 11-11, 11-11, 11-10, 11-10, 5-5, the last a very small specimen. Three tail valves show 14 slits each, radial ribs respectively 7, 6, 5, and longitudinal riblets on central areas 8-9, 6-7, 4-4.

The teeth of *Callistochiton*, as evidenced by the present species, seem to be composed of a somewhat different substance from the more spongy deposit which fills in the slits, so even when quite worn down it is quite possible to distinguish their number and shape (in transection) with perfect accuracy, especially if the surfaces in question are slightly moistened, when the details are brought out with great clearness. This is fortunate as in most fossil specimens the teeth show as little more than a *pattern*, scarcely worthy of the name teeth at all.

Caliper measurements of some of the larger specimens are as follows:

		Length	Diameter	Height
Head valve	[349]	3.5 mm.	5.7 mm.	3.4 mm.
Median valve	[512]	3.2	6.7	3.2
" "	[646]	4.8	7.6	4.1
" "	[679]	4.3	8.3	4.7
" "	[1024]	4.2	7.8	3.8
Tail valve	[515]	4.0	5.2	2.4
" "	[680]	5.7	7.7	3.4

35. **Callistochiton palmulatus mirabilis** Pilsbry, 1893

(Plate XIV, figs. 9-16; Plate XV.)

1893. *Callistochiton palmulatus* var. *mirabilis* Pilsbry, Man. Conch., (1), v. 14, p. 263, pl. 58, f. 7-11.

1917. *Callistochiton palmulatus* and var. *mirabilis* Chace, Lorquinia, v. 2, p. 30 (recorded from Pleistocene of Santa Monica, Cal.).

Diagnosis: Valves small, thick, massive, elevated, carinated; side slopes slightly convex; lateral areas elevated, divided by a strong median sulcus into two nodulose ribs, each sometimes with a secondary furrow on the summit; head valve strongly elevated, primarily with 9 strongly tubercular, eventually sulcate, radial ribs; central areas with 14-18 moderately strongly

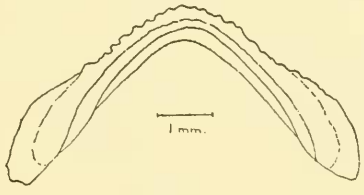

Fig. 11

Fig. 11. *Callistochiton palmulatus mirabilis* Pilsbry. Anterior elevation of valve illustrated in Plate XIV, figs. 15-16.

interlatticed ribs on each side, subparallel except on the jugum of valve ii, where they diverge; tail valve with mucro in front of middle, the abbreviated central area much lower than the swollen posterior region; sutural plates very short, connected across the shallow narrow sinus; teeth short, curved, slightly projecting in valves i-vii, extremely robust and thick in valve viii; eaves wide, solid; slits 9, 1-1, 18 to 25, with distinct pore lines leading into them.

Recorded Range:

Pleistocene: Lower San Pedro Series—Nob Hill Cut, San Pedro, California (!).

Upper San Pedro Series—Long Wharf Canyon, Santa Monica, California (Chace, !); Los Cerritos Hill, Long Beach, California (!).

Formation doubtful— Deadman Island, San Pedro, California (!).

Living: Monterey, California (!), to San Diego, California (!); between tides to 15 fathoms.

Material Examined:

No. of Specimens	Valve	Locality	Collector	Where Deposited	Number in Author's Register	Formation	Period
2	Int..	Nob Hill Cut, San Pedro, Cal.	Oldroyd Coll.	Dept. Geology, Stanford Univ.	[649]	Lower San Pedro...	Pleistocene
2	Ant..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	Berry Coll. Cat. 3929.	[522]	Upper San Pedro...	Pleistocene
13	Ant..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	Berry Coll. Cat. 3930.	[523]	Upper San Pedro...	Pleistocene
90	Ant..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	F. C. Clark Coll.	[524]	Upper San Pedro...	Pleistocene
1	Int..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	Berry Coll. Cat. 3929.	[525]	Upper San Pedro...	Pleistocene
4	Int..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	Berry Coll. Cat. 3930.	[526]	Upper San Pedro...	Pleistocene
12	Int..	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	F. C. Clark Coll.	[527]	Upper San Pedro...	Pleistocene
6	Post.	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	Berry Coll. Cat. 3929.	[528]	Upper San Pedro...	Pleistocene
12	Post.	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	Berry Coll. Cat. 3930.	[529]	Upper San Pedro...	Pleistocene
57	Post.	Long Wharf Canyon, Santa Monica, Cal.	F. C. Clark	F. C. Clark Coll.	[530]	Upper San Pedro...	Pleistocene
1	Post.	Los Cerritos Hill, Long Beach, Cal.	T. S. Oldroyd	Dept. Geology, Stanford Univ.	[663]	Upper San Pedro...	Pleistocene
1	Int..	Deadman Id., San Pedro, Cal.	Arnold Coll.	Dept. Geology, Stanford Univ.	[681]	?	? Pleistocene
72	Post.	Deadman Id., San Pedro, Cal.	Arnold Coll.	Dept. Geology, Stanford Univ.	[716]	?	? Pleistocene

Remarks: This species or subspecies has already received some attention in the course of the discussion of the last species, but a few more notes deserve to be recorded.

For one thing I am not yet altogether sure that *mirabilis* is entirely worthy of subspecific separation from *palmulatus* Carpenter. On the other hand I am no more positive but that it may eventually prove specifically distinct. This seems paradoxical but is a situation which logically follows from the conflicting evidence afforded by our scanty data. While it is true that the majority of the fossil specimens fall without debate under Pilsbry's diagnosis, and it further appears that none of the specimens, unless very doubtfully some of the juvenals, accord entirely with his description of typical *palmulatus*, still the number of specimens which in one or more particulars are intermediate between the two is legion. My experience with recent specimens is that they are often even more troublesome to separate. Without exception all the characters depended upon to distinguish the two forms are subject to much

variation. On the other hand the features separating the *palmulatus* complex from *crassicostatus* seem dependable enough. These two facts are brought out rather forcefully in the following summary of observations made on Dr. Clark's numerous Santa Monica specimens.

Sixty-six head valves of the Long Wharf Canyon *mirabilis* have 9 ribs and 9 slits to correspond, though the two outermost ribs are in each case apparently duplex, and counting each of these as 2 would raise the number of ribs to 11. Fifteen others have 9 ribs each, but the number of slits could not be accurately determined. Two have 9 ribs, 9 slits to correspond, and a supernumerary slit between two of the ribs. Four have the usual 9 ribs, but 10 slits, due to a double slit opposite one of the ribs, the position of the rib so favored being variable. A single valve has 10 ribs and 10 corresponding slits.

Ten median valves show variations in the number of longitudinal ribs on each side as follows: 18-18, 17-16, 16-16, 16-15, 15-15, 15-15, 14-14, 14-14, 14-14, 10-10. The number apparently depends in considerable degree upon the size of the specimen.

One tail valve shows 12 longitudinal riblets to a side on the central area, 2 show 11, 2 show 10, 8 show 9, 8 show 8, 5 show 7, and 2 show 6, none showing less than 6. Here again there seems to be a certain degree of correlation, not entirely absolute, between the number of these riblets and the size of the specimen. Twenty-five tail valves show 5 radial ribs, all at first simple, but soon divided by a strong median furrow, secondary furrows being sometimes developed later on each side of the primary one. In the outermost pair of ribs on one or two of these specimens the central furrows commence so early that the total number of ribs could easily be stated as 7. Two valves clearly have 7 ribs. Fifteen specimens have 6 ribs, the 2 central ribs in such cases being usually very evidently homologous with the single median rib of the 5-ribbed specimens. This is shown by the pair in question being very close together, while neither develops its median furrow as early as the remaining ribs do. Turning to the insertion plates, 7 valves have 25 slits each, 9 have 24, 9 have 25, 4 have 22, 1 has 21, 4 have 20, 4 have 19, 2 have 18, and 1 has 16. The mode

seems to lie in remarkable proximity to the maximum in a curve plotted on this basis.

The position of the mucro is very constant, but the degree of elevation of the posterior area is extremely variable. The accompanying series of figures (Plate XV, figs. 1-12) is designed to illustrate this.

When eroded to the proper degree, the radiating tubercles of this species show each a distinct central pore or lumen.

This is by all odds our most abundant fossil chiton, even though this is entirely due to its enormous frequency in the Upper San Pedro of Long Wharf Canyon, Santa Monica. An amazing circumstance in this connection is the great preponderance of head and tail valves among the specimens collected (see foregoing table). Why only 17 out 197 specimens quarried should be median valves, when the latter must originally have been exactly three times as numerous as the terminal ones, is not easy to understand. It is true that they are much less heavy and solid, but as broken fragments are not more common in the one case than the other, this does not seem an entirely sufficient explanation. To a less degree the same phenomenon is likewise true of *C. crassicostatus* in these beds.

The largest specimens taken have the following caliper measurements:

		Length	Diameter	Height
Head valve	[522]	3.4 mm.	5.2 mm.	3.4 mm.
Median valve	[526]	2.7	6.8	3.6
Tail valve	[529]	4.2	4.7	3.3
" "	[528]	3.5	5.0	2.6

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EXPLANATION OF PLATES

PLATE I.

Fig. 1. *Oligochiton lioplax* Berry, n. sp. Exterior view of head valve from Loc. N. P. 129 [606], in situ.

Fig. 2. *Oligochiton lioplax* Berry, n. sp. Same valve after delamination and removal of tegmentum; same scale as preceding.

Fig. 3. *Oligochiton lioplax* Berry, n. sp. Exterior view of median valve from Loc. N. P. 129 [607], in situ; same scale as preceding.

Fig. 4. *Oligochiton lioplax* Berry, n. sp. Interior view of right side of same valve, showing radial lines; same scale as preceding.

Fig. 5. *Oligochiton lioplax* Berry, n. sp. Exterior view of tail valve from Loc. N. P. 129, type specimen [608], after removal from matrix; same scale as preceding.

Fig. 6. *Oligochiton lioplax* Berry, n. sp. Interior view of same valve; same scale as preceding.

Fig. 7. *Lepidochitona denticns* (Gould). Exterior view of median valve from Nob Hill Cut, San Pedro, California (Lower San Pedro Pleistocene) [659].

Fig. 8. *Lepidochitona denticns* (Gould). Interior view of same valve; same scale as preceding.

Fig. 9. *Lepidochitona denticns* (Gould). Anterior elevation of same valve; camera outline.

Fig. 10. *Leptochiton clarki* Berry, n. sp. Enlarged view of sculpture detail from right side of intermediate valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene); type specimen [605].


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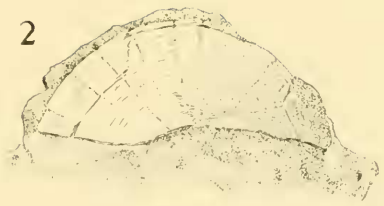
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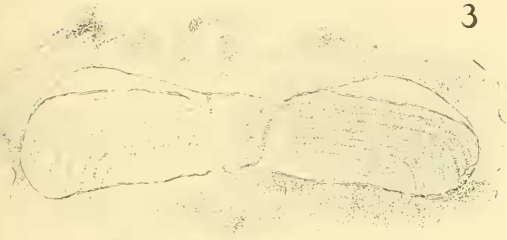
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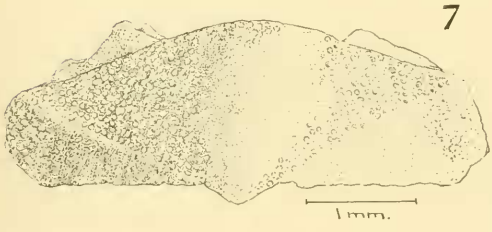
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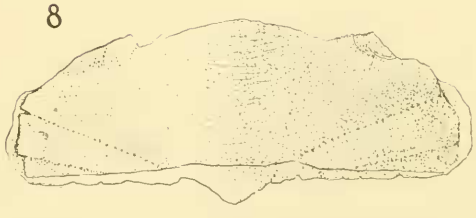
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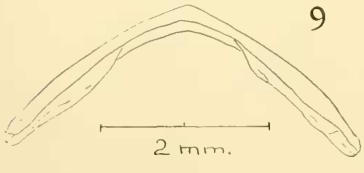
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Plate II.

Fig. 1. *Tonicella lineata* (Wood). Exterior view of median valve from near lighthouse, Point Fermin, California (Lower San Pedro Pleistocene) [1096].

Fig. 2. *Tonicella lineata* (Wood). Interior view of same valve; same scale as preceding.

Fig. 3. *Tonicella lineata* (Wood). Anterior elevation of same valve; camera outline.

Fig. 4. *Tonicella lineata* (Wood). Exterior view of tail valve from near lighthouse, Point Fermin, California (Lower San Pedro Pleistocene) [1097]; same scale as Fig. 1.

Fig. 5. *Tonicella lineata* (Wood). Profile of same valve; camera outline.

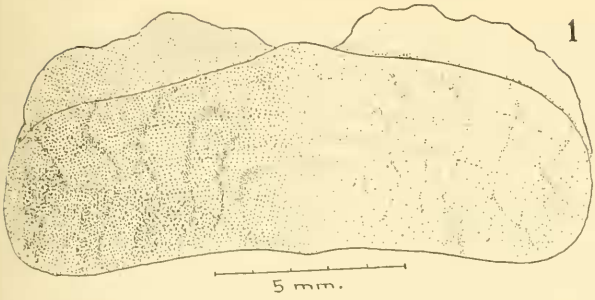
Fig. 6. *Cyanoplax hartwegii* (Carpenter). Exterior view of median valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [943]; same scale as Fig. 1.

Fig. 7. *Cyanoplax hartwegii* (Carpenter). Interior view of same valve; camera outline.

Fig. 8. *Cyanoplax hartwegii* (Carpenter). Anterior elevation of same valve; camera outline.

Fig. 9. *Cyanoplax fackenthallæ* Berry. Oblique anterior view of head valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [1082].

Fig. 10. *Cyanoplax fackenthallæ* Berry. Profile of same valve; camera outline.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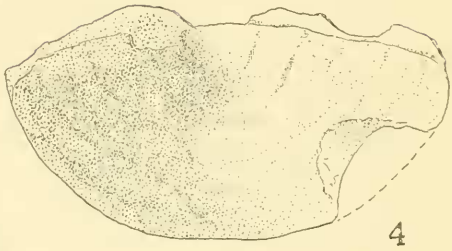
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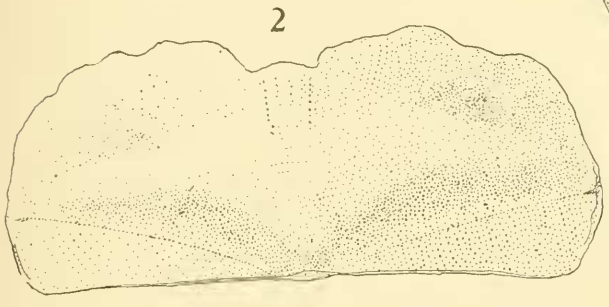
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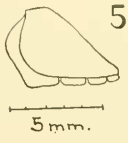
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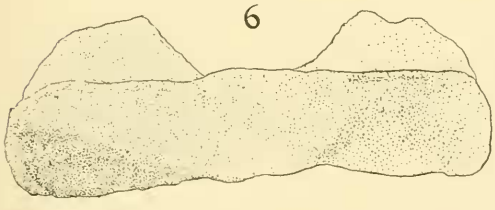
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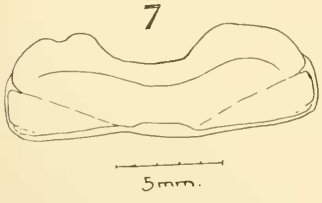
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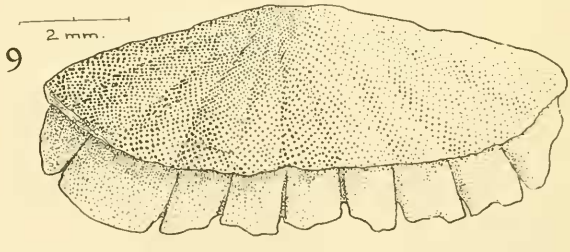
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Plate III.

Fig. 1. *Nuttallina californica* (Nuttall). Exterior view of head valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [1026].

Fig. 2. *Nuttallina californica* (Nuttall). Interior view of same valve; same scale as preceding.

Fig. 3. *Nuttallina californica* (Nuttall). Profile of same valve; camera outline.

Fig. 4. *Nuttallina californica* (Nuttall). Exterior view of median valve from Nob Hill Cut, San Pedro, California (Lower San Pedro Pleistocene) [653]; same scale as Fig. 1.

Fig. 5. *Nuttallina californica* (Nuttall). Interior view of same valve; same scale as preceding.

Fig. 6. *Nuttallina californica* (Nuttall). Anterior elevation of same valve; camera outline.

Fig. 7. *Nuttallina californica* (Nuttall). Exterior view of tail valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [1028]; same scale as Fig. 1.

Fig. 8. *Nuttallina californica* (Nuttall). Interior view of same valve; same scale as preceding.

Fig. 9. *Nuttallina californica* (Nuttall). Profile of same valve; camera outline.

Fig. 10. *Nuttallina californica* (Nuttall). Exterior view of median valve of a less mature individual from Deadman Island, San Pedro, California (probably Pleistocene) [678]; camera outline showing shape of uneroded valve.

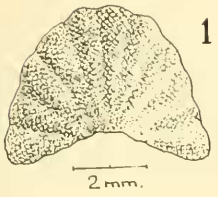
Fig. 11. *Nuttallina californica* (Nuttall). Interior view of same; camera outline; same scale as preceding.

Fig. 12. *Nuttallina californica* (Nuttall). Anterior elevation of same valve; camera outline; same scale as preceding.

Fig. 13. *Placiphorella velata* Carpenter. Exterior view of median valve from Deadman Island, San Pedro, California (probably Pleistocene) [677].

Fig. 14. *Placiphorella velata* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 15. *Placiphorella velata* Carpenter. Anterior elevation of same valve; camera outline.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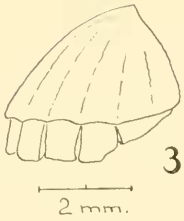
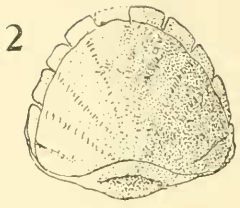

3
2 mm.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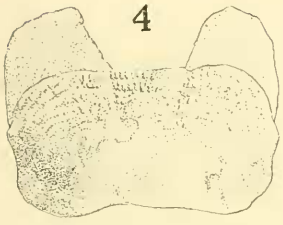
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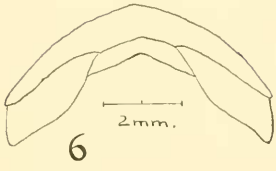
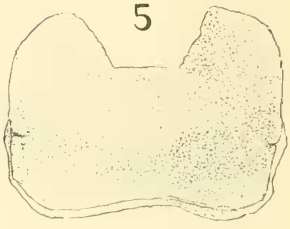

2mm.
6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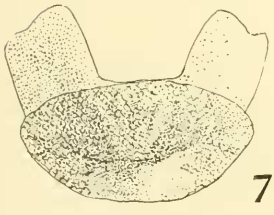
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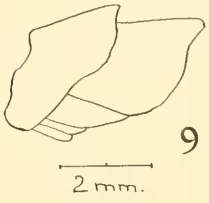
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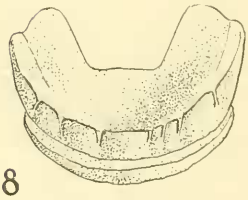
2 mm.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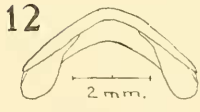
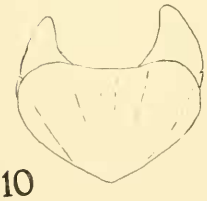

12
2 mm.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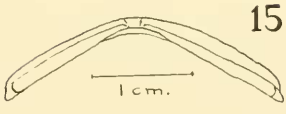
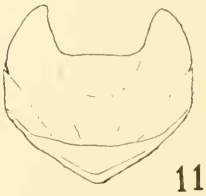

15
1 cm.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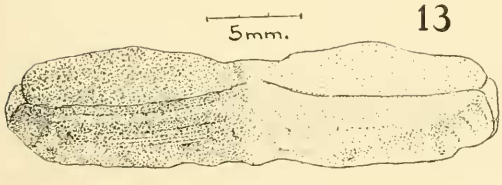

5mm.
13

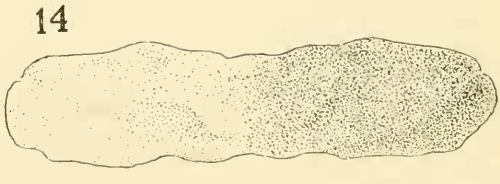

14

Plate IV.

Fig. 1. *Mopalia muscosa* (Gould). Exterior view of head valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [1034]; viewed from somewhat obliquely toward the front.

Fig. 2. *Mopalia muscosa* (Gould). Interior view of same valve; same scale as preceding.

Fig. 3. *Mopalia muscosa* (Gould). Profile of same valve; camera outline.

Fig. 4. *Mopalia muscosa* (Gould). Exterior view of median valve from "coal mine", west side of Point Loma, California (Upper San Pedro Pleistocene) [550].

Fig. 5. *Mopalia muscosa* (Gould). Interior view of same valve; same scale as preceding.

Fig. 6. *Mopalia muscosa* (Gould). Anterior elevation of same valve; camera outline.

Fig. 7. *Mopalia muscosa* (Gould). Exterior view of tail valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [1090].

Fig. 8. *Mopalia muscosa* (Gould). Interior view of same valve; same scale as preceding.

Fig. 9. *Mopalia muscosa* (Gould). Profile of same valve; camera outline.

Fig. 10. *Mopalia hindsii* (Sowerby). Exterior view of second valve from Deadman Island, San Pedro, California (Pleistocene) [578]; same scale as Fig. 4.

Fig. 11. *Mopalia hindsii* (Sowerby). Interior view of same valve; same scale as preceding.

Fig. 12. *Mopalia hindsii* (Sowerby). Anterior elevation of same valve; camera outline.

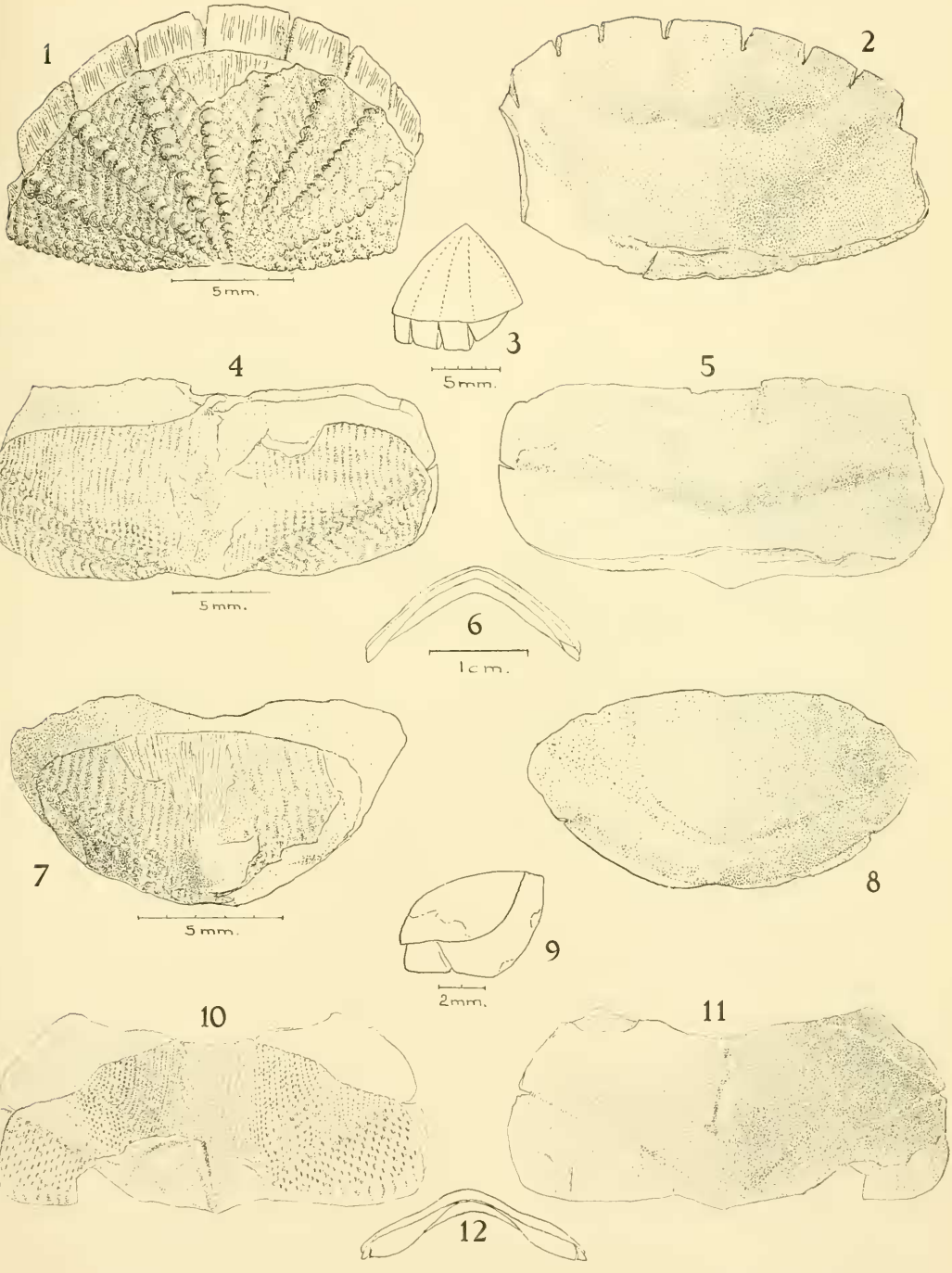

1
5mm.
2
3
5mm.
4
5mm.
5
6
1cm.
7
5mm.
8
9
2mm.
10
11
12

Plate V.

Fig. 1. *Mopalia ciliata* (Sowerby). Exterior view of head valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [1036].

Fig. 2. *Mopalia ciliata* (Sowerby). Interior view of same valve; same scale as preceding.

Fig. 3. *Mopalia ciliata* (Sowerby). Profile of same valve; camera outline.

Fig. 4. *Mopalia ciliata* (Sowerby). Exterior view of median valve, probably from Deadman Island, San Pedro, California (Pleistocene) [676].

Fig. 5. *Mopalia ciliata* (Sowerby). Interior view of same valve; same scale as preceding.

Fig. 6. *Mopalia ciliata* (Sowerby). Anterior elevation of same valve; camera outline.

Fig. 7. *Mopalia ciliata* (Sowerby). Exterior view of tail valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [1038]; same scale as Fig. 1.

Fig. 8. *Mopalia ciliata* (Sowerby). Interior view of same valve; same scale as preceding.

Fig. 9. *Mopalia ciliata* (Sowerby). Profile of same valve; camera outline.

Fig. 10. *Mopalia acuta* (Carpenter). Exterior view of median valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [762].

Fig. 11. *Mopalia acuta* (Carpenter). Interior view of same valve; same scale as preceding.

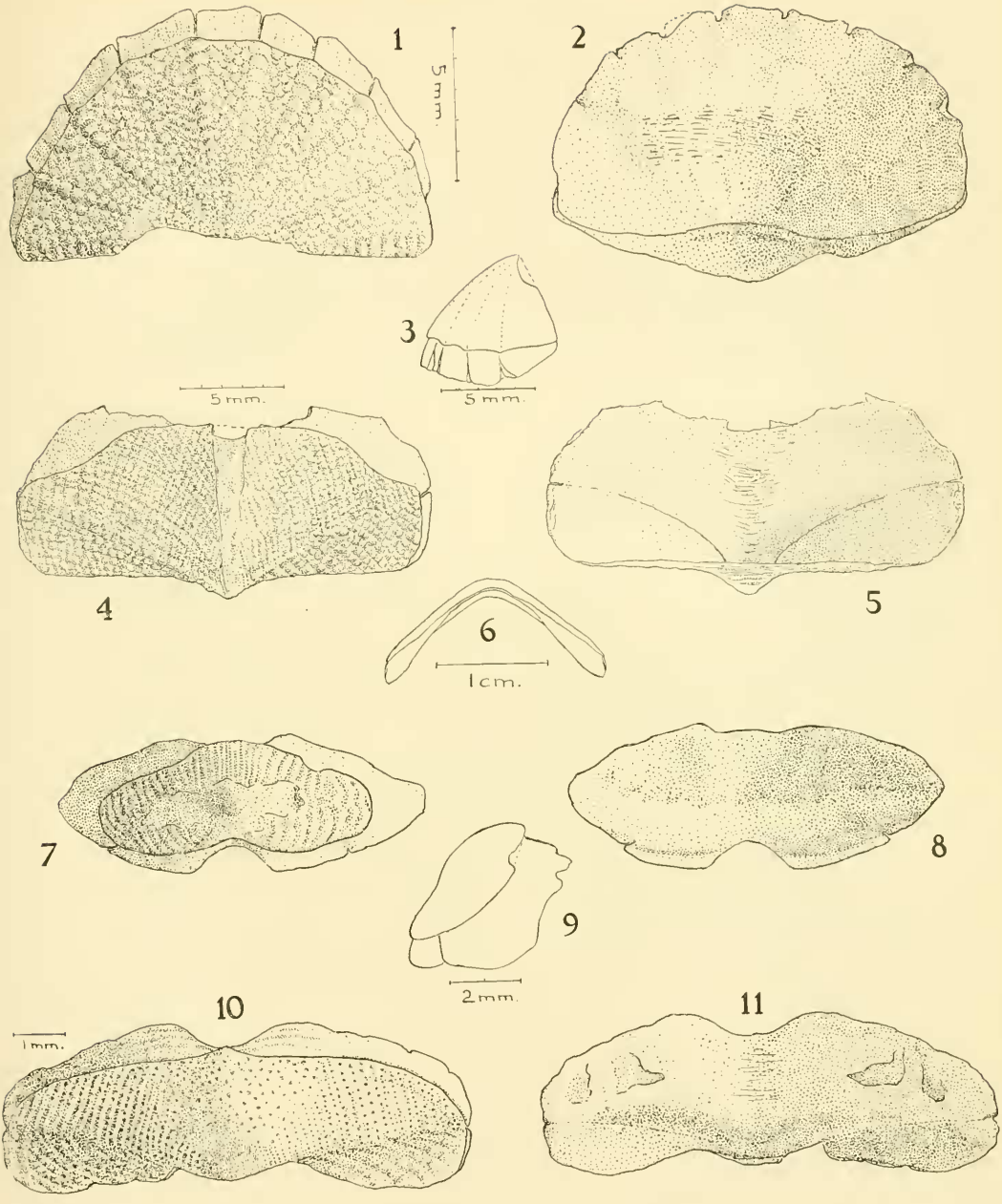

1
5 mm.
2
3
5 mm.
5 mm.
4
5
6
1 cm.
7
8
9
2 mm.
10
1 mm.
11

Plate VI.

Fig. 1. *Katharina tunicata* (Wood). Exterior view of head valve from Deadman Island, San Pedro, California (Pleistocene) [345]; tegmentum lost from this specimen.

Fig. 2. *Katharina tunicata* (Wood). Interior view of same valve; same scale as preceding.

Fig. 3. *Katharina tunicata* (Wood). Profile of same valve; camera outline.

Fig. 4. *Katharina tunicata* (Wood). Exterior of median valve from Deadman Island, San Pedro, California (Santa Barbara Pliocene) [726].

Fig. 5. *Katharina tunicata* (Wood). Interior of same valve; same scale as preceding.

Fig. 6. *Katharina tunicata* (Wood). Anterior elevation of same valve; camera outline.

Fig. 7. *Mopalia* cf. *sinuata* (Carpenter). Lateral view of head valve from Deadman Island, San Pedro, California (probably Pleistocene) [717].

Fig. 8. *Mopalia* cf. *sinuata* (Carpenter). Sculptural detail of same specimen, greatly magnified.

Fig. 9. *Acanthochitona avicula* (Carpenter). Exterior of imperfect median valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [940].

Fig. 10. *Cryptochiton stelleri* (Middendorff). Interior view of head valve from C. A. S. Loc. 108, 2 miles north of Point Loma, California (Upper San Pedro Pleistocene) [517]; showing radial lines made visible by delamination of inner layer of articulamentum.

Fig. 11. *Cryptochiton stelleri* (Middendorff). Exterior of median valve from Pacific Beach, San Diego County, California (San Diego Pliocene) [505]; camera outline.

Fig. 12. *Cryptochiton stelleri* (Middendorff). Exterior view of tail valve from Nob Hill Cut, San Pedro, California (Lower San Pedro Pleistocene) [644]; camera outline.

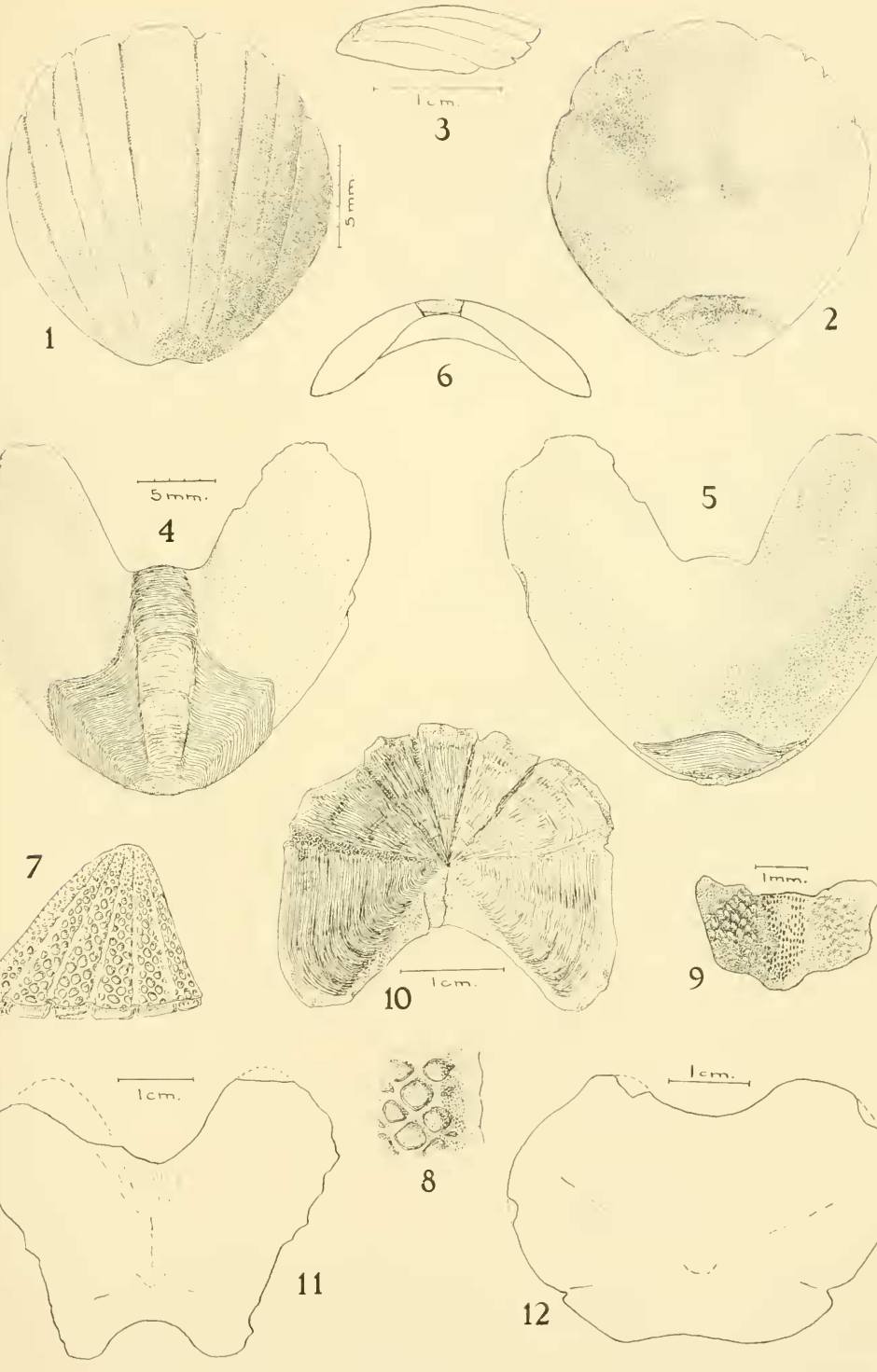

1
5mm.
3
1cm.
2
6
4
5mm.
5
7
10
1cm.
9
1mm.
11
1cm.
8
12
1cm.

Plate VII.

Fig. 1. *Ischnochiton fallax* Carpenter. Exterior view of median valve from Nob Hill Cut, San Pedro, California (Lower San Pedro Pleistocene) [650].

Fig. 2. *Ischnochiton fallax* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 3. *Ischnochiton fallax* Carpenter. Anterior elevation of same valve; camera outline.

Fig. 4. *Ischnochiton magdalenensis* (Hinds). Exterior view of head valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [946]; same scale as Fig. 1.

Fig. 5. *Ischnochiton magdalenensis* (Hinds). Profile of same valve; camera outline.

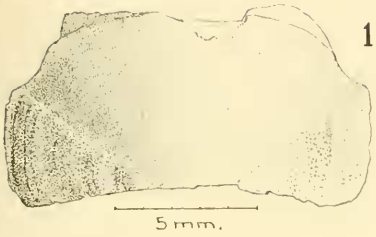
Fig. 6. *Ischnochiton magdalenensis* (Hinds). Exterior view of median valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [1086]; same scale as Fig. 1.

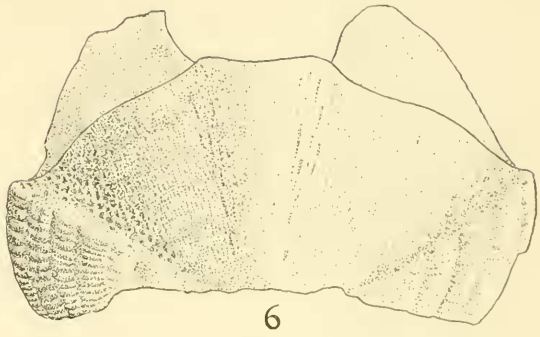
Fig. 7. *Ischnochiton magdalenensis* (Hinds). Interior view of same valve; same scale as preceding.

Fig. 8. *Ischnochiton magdalenensis* (Hinds). Anterior elevation of same valve; camera outline.

Fig. 9. *Ischnochiton magdalenensis* (Hinds). Exterior view of tail valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [1087]; same scale as Fig. 1.

Fig. 10. *Ischnochiton magdalenensis* (Hinds). Profile of same valve; camera outline.


1
5 mm.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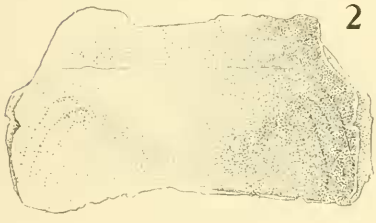
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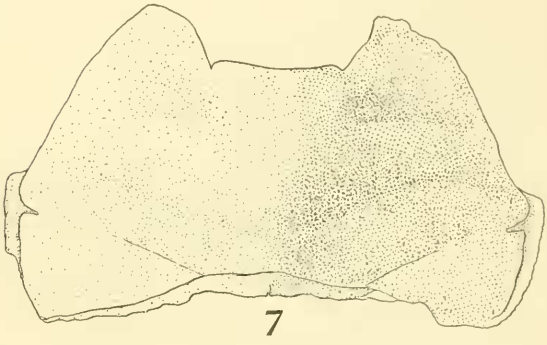
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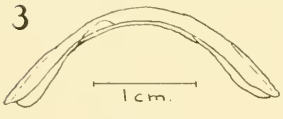
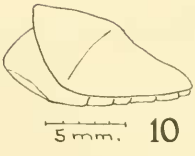
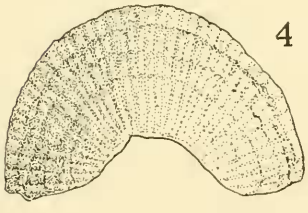

3
1 cm.


5 mm.
10


8
5 mm.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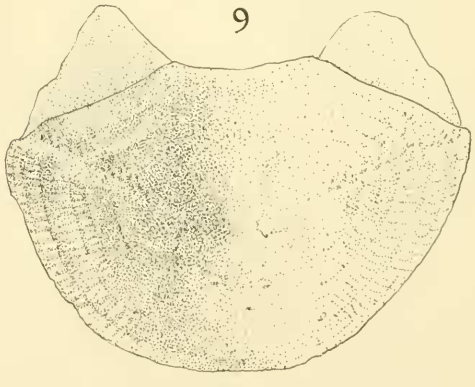

9

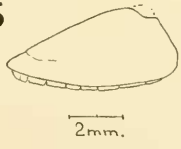

5
2mm.

Plate VIII.

Fig. 1. *Ischnochiton conspicuus* Carpenter. Exterior view of head valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [350].

Fig. 2. *Ischnochiton conspicuus* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 3. *Ischnochiton conspicuus* Carpenter. Profile of same view; camera outline.

Fig. 4. *Ischnochiton conspicuus* Carpenter. Exterior view of median valve from "coal mine", west side of Point Loma, California (Upper San Pedro Pleistocene) [499].

Fig. 5. *Ischnochiton conspicuus* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 6. *Ischnochiton conspicuus* Carpenter. Anterior elevation of same valve; camera outline.

Fig. 7. *Ischnochiton conspicuus* Carpenter. Exterior view of tail valve from Deadman Island, San Pedro, California (Pleistocene) [346]; same scale as Fig. 1.

Fig. 8. *Ischnochiton conspicuus* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 9. *Ischnochiton conspicuus* Carpenter. Profile of same valve; camera outline.

Fig. 10. *Chactopleura gemma* Carpenter. Exterior view of median valve from Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [1025].

Fig. 11. *Chactopleura gemma* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 12. *Chactopleura gemma* Carpenter. Anterior elevation of same valve; camera outline.

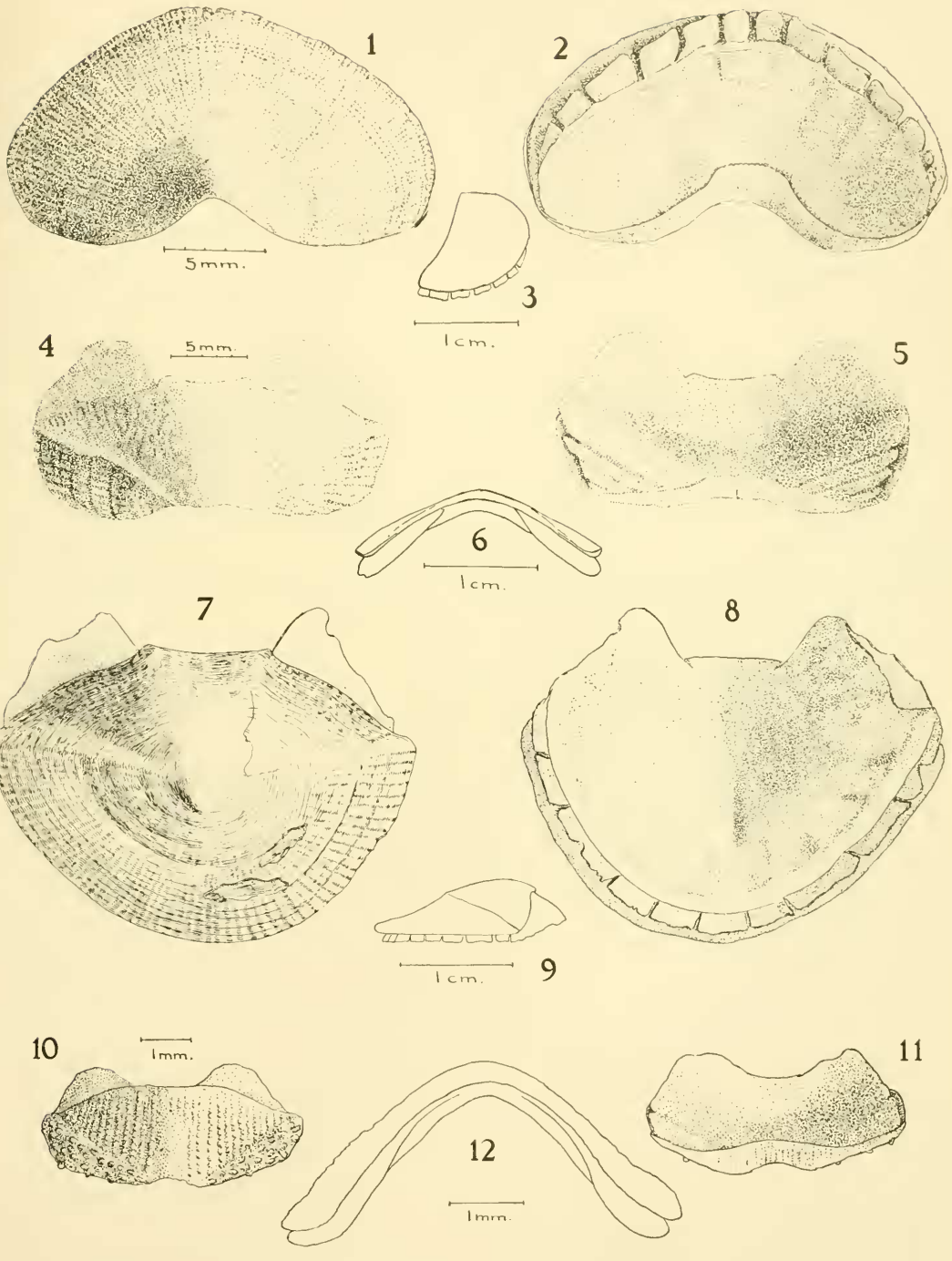

1
5mm.
2
3
1cm.
4
5mm.
5
6
1cm.
7
8
1cm.
9
10
1mm.
11
12
1mm.

Plate IX.

Fig. 1. *Ischnochiton acrior* Carpenter. Exterior view of head valve from Deadman Island, San Pedro, California (probably Pleistocene) [685].

Fig. 2. *Ischnochiton acrior* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 3. *Ischnochiton acrior* Carpenter. Profile of same valve; camera outline.

Fig. 4. *Ischnochiton acrior* Carpenter. Exterior view of median valve from "coal mine", west side of Point Loma, California (Upper San Pedro Pleistocene) [343].

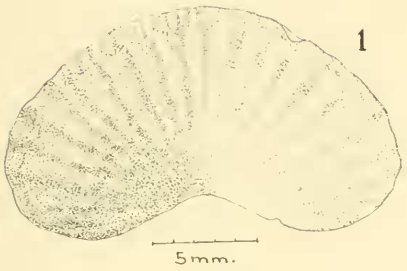
Fig. 5. *Ischnochiton acrior* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 6. *Ischnochiton acrior* Carpenter. Anterior elevation of same valve; camera outline.

Fig. 7. *Ischnochiton acrior* Carpenter. Exterior view of fragmentary tail valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [352]; same scale as Fig. 1.

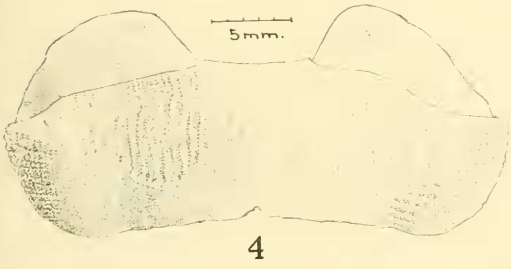
Fig. 8. *Ischnochiton acrior* Carpenter. Interior view of same valve; same scale as preceding.

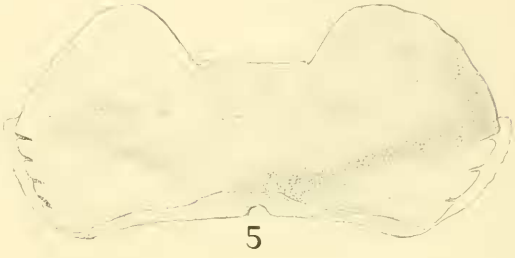
Fig. 9. *Ischnochiton acrior* Carpenter. Profile of same valve; camera outline.


1
5mm.


2


3
1cm.


5mm.
4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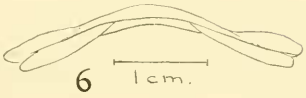
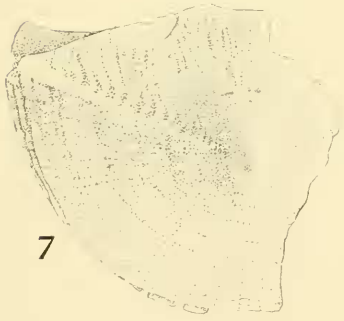

6
1cm.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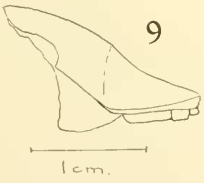

9
1cm.

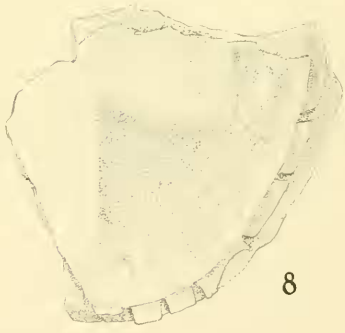

8

Plate X.

Fig. 1. *Ischnochiton acrior* Carpenter. Exterior view of median valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [344].

Fig. 2. *Ischnochiton acrior* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 3. *Ischnochiton acrior* Carpenter. Anterior elevation of same valve; camera outline.

Fig. 4. *Ischnochiton pectinulatus* (Carpenter). Exterior view of second valve from Spanish Bight, San Diego, California (Upper San Pedro Pleistocene) [507].

Fig. 5. *Ischnochiton pectinulatus* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 6. *Ischnochiton pectinulatus* Carpenter. Anterior elevation of same valve; camera outline.

Fig. 7. *Ischnochiton mertensii* (Middendorff). Exterior view of median valve from Deadman Island, San Pedro, California (probably Pleistocene) [709]; same scale as Fig. 4.

Fig. 8. *Ischnochiton mertensii* (Middendorff). Interior view of same valve; same scale as preceding.

Fig. 9. *Ischnochiton mertensii* (Middendorff). Anterior elevation of same valve; camera outline.

Fig. 10. *Ischnochiton mertensii* (Middendorff). Exterior view of tail valve from Deadman Island, San Pedro, California (probably Pleistocene) [710]; same scale as Fig. 4.

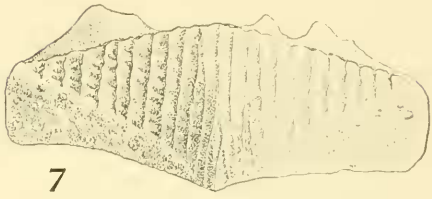
Fig. 11. *Ischnochiton mertensii* (Middendorff). Interior view of same valve; same scale as preceding.

Fig. 12. *Ischnochiton mertensii* (Middendorff). Profile of same valve; camera outline.


5mm.
1

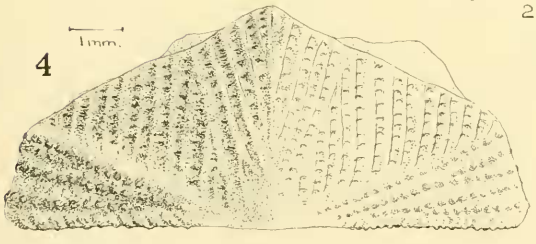

3
1cm.

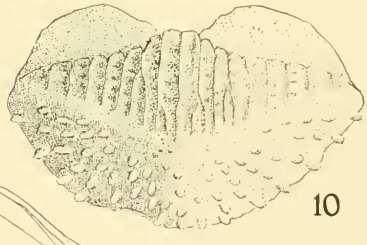

2


7


8


2mm.
9


1mm.
4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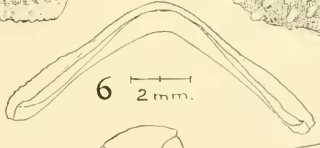

6
2mm.


5


2mm
12


11

Plate XI.

Fig. 1. *Ischnochiton cooperi* Carpenter. Exterior view of head valve from Deadman Island, San Pedro, California (probably Pleistocene) [722].

Fig. 2. *Ischnochiton cooperi* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 3. *Ischnochiton cooperi* Carpenter. Profile of same valve: camera outline.

Fig. 4. *Ischnochiton cooperi* Carpenter. Exterior view of median valve from Deadman Island, San Pedro, California (probably Pleistocene) [723].

Fig. 5. *Ischnochiton cooperi* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 6. *Ischnochiton cooperi* Carpenter. Anterior elevation of same valve; camera outline.

Fig. 7. *Ischnochiton cooperi* Carpenter. Exterior view of median valve, probably from Deadman Island, San Pedro, California (Pleistocene) [648].

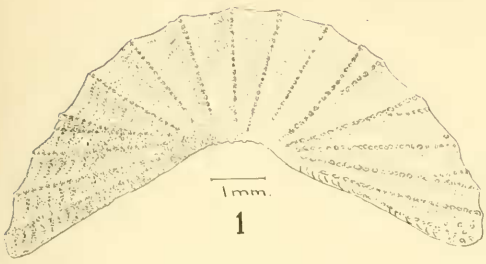
Fig. 8. *Ischnochiton cooperi* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 9. *Ischnochiton cooperi* Carpenter. Anterior elevation of same valve; camera outline.

Fig. 10. *Ischnochiton cooperi* Carpenter. Exterior view of tail valve from Deadman Island, San Pedro, California (probably Pleistocene) [730].

Fig. 11. *Ischnochiton cooperi* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 12. *Ischnochiton cooperi* Carpenter. Profile of same valve; same scale as preceding.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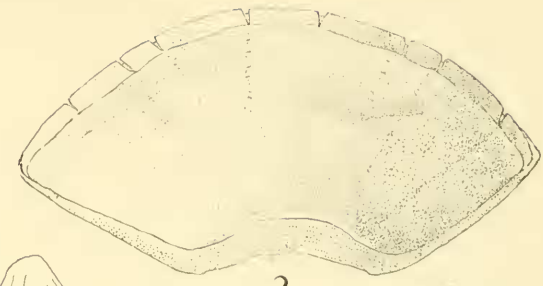
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2 mm.
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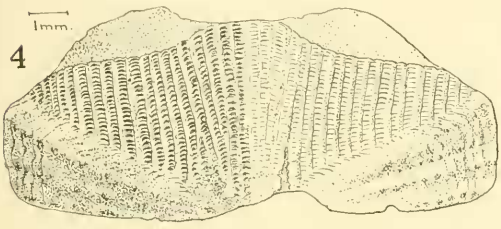
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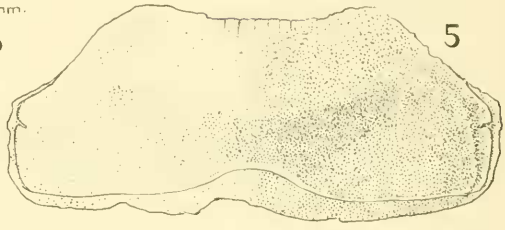
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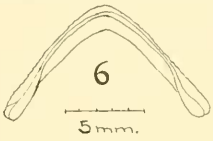
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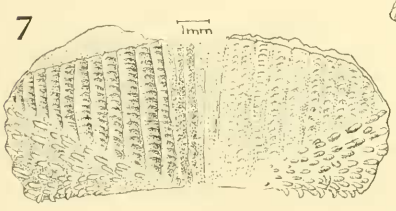
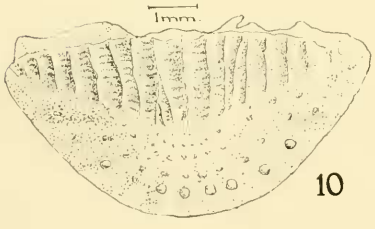

1mm
7


8


9
5mm.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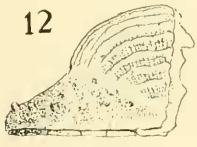

12


11

Plate XII.

Fig. 1. *Ischnochiton sanctaemonicae* Berry, n. sp. Exterior view of head valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene); paratype [881].

Fig. 2. *Ischnochiton sanctaemonicae* Berry, n. sp. Interior view of same valve; same scale as preceding.

Fig. 3. *Ischnochiton sanctaemonicae* Berry, n. sp. Profile of same valve; camera outline.

Fig. 4. *Ischnochiton sanctaemonicae* Berry, n. sp. Exterior view of type specimen, a median valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [883]; same scale as Fig. 1.

Fig. 5. *Ischnochiton sanctaemonicae* Berry, n. sp. Interior view of same valve; same scale as preceding.

Fig. 6. *Ischnochiton sanctaemonicae* Berry, n. sp. Anterior elevation of same valve; camera outline.

Fig. 7. *Ischnochiton sanctaemonicae* Berry, n. sp. Exterior view of tail valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene); paratype [886]; same scale as Fig. 1.

Fig. 8. *Ischnochiton sanctaemonicae* Berry, n. sp. Interior view of same valve; same scale as preceding.

Fig. 9. *Ischnochiton sanctaemonicae* Berry, n. sp. Profile of same valve; camera outline.

Fig. 10. *Ischnochiton* cf. *sinudentatus* Carpenter. Exterior view of head valve from Deadman Island, San Pedro, California (probably Pleistocene) [704]; same scale as Fig. 1.

Fig. 11. *Ischnochiton* cf. *sinudentatus* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 12. *Ischnochiton* cf. *sinudentatus* Carpenter. Profile of same valve; camera outline.

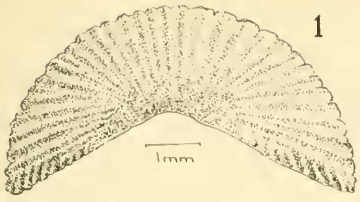
Fig. 13. *Ischnochiton* cf. *sinudentatus* Carpenter. Exterior view of median valve from Deadman Island, San Pedro, California (probably Pleistocene) [705]; same scale as Fig. 1.

Fig. 14. *Ischnochiton* cf. *sinudentatus* Carpenter. Interior view of same valve; same scale as preceding.

Fig. 15. *Ischnochiton* cf. *sinudentatus* Carpenter. Anterior elevation of same valve; camera outline.

Fig. 16. *Ischnochiton* cf. *sinudentatus* Carpenter. Anterior elevation of another valve from same lot [705]; camera outline.

Fig. 17. *Ischnochiton* cf. *sinudentatus* Carpenter. Profile of tail valve from Deadman Island, San Pedro, California (probably Pleistocene) [706]; camera outline.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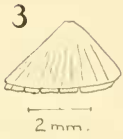
1mm


2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2 mm.


4


5


2 mm.
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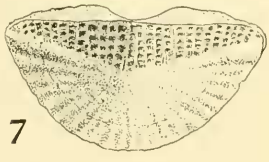
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2 mm.


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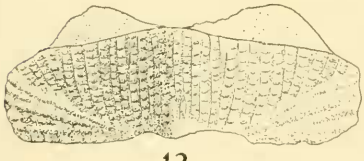
2 mm.


11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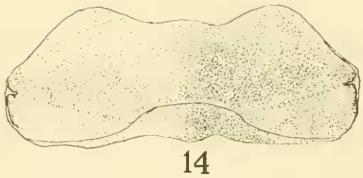

14


15
2 mm.


16
2 mm.


17
2 mm.

Plate XIII.

Fig. 1. *Callistochiton crassicostatus* Pilsbry. Dorsal view of head valve from "coal mine", west side of Point Loma, California (Upper San Pedro Pleistocene) [349].

Fig. 2. *Callistochiton crassicostatus* Pilsbry. Profile of same valve; same scale as preceding.

Fig. 3. *Callistochiton crassicostatus* Pilsbry. Interior view of same valve; same scale as preceding.

Fig. 4. *Callistochiton crassicostatus* Pilsbry. Dorsal view of less mature head valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [509]; same scale as preceding.

Fig. 5. *Callistochiton crassicostatus* Pilsbry. Interior view of same valve; same scale as preceding.

Fig. 6. *Callistochiton crassicostatus* Pilsbry. Exterior view of median valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [512].

Fig. 7. *Callistochiton crassicostatus* Pilsbry. Interior view of same valve; same scale as preceding.

Fig. 8. *Callistochiton crassicostatus* Pilsbry. Exterior view of tail valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [515a]; same scale as Fig. 1.

Fig. 9. *Callistochiton crassicostatus* Pilsbry. Right lateral view of same valve; same scale as preceding.

Fig. 10. *Callistochiton crassicostatus* Pilsbry. Interior view of same valve; same scale as preceding.

Fig. 11. *Callistochiton crassicostatus* Pilsbry. Exterior view of less mature tail valve from same lot [515b]; same scale as preceding.

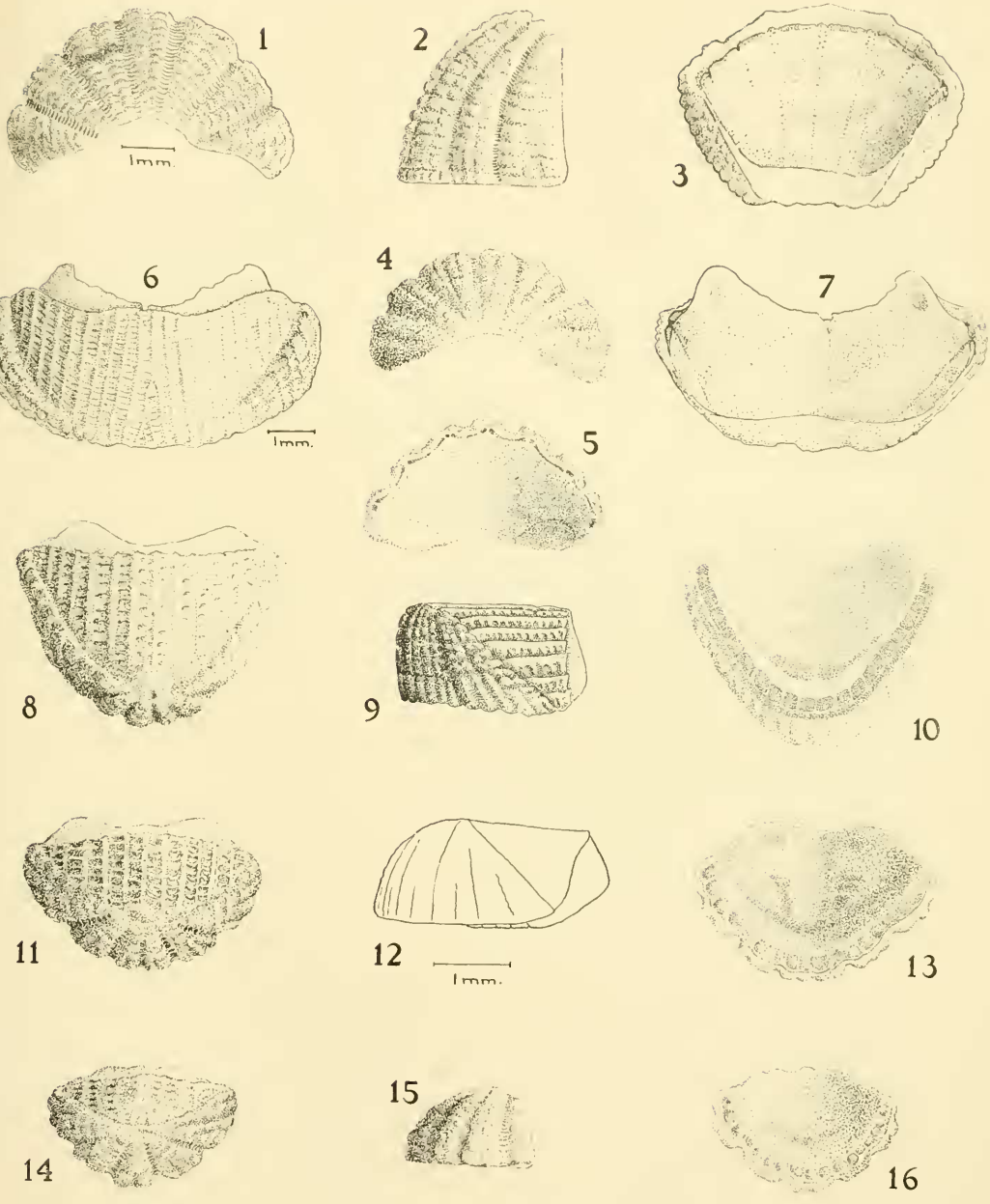
Fig. 12. *Callistochiton crassicostatus* Pilsbry. Profile of same valve; camera outline.

Fig. 13. *Callistochiton crassicostatus* Pilsbry. Interior view of same valve; same scale as Fig. 11.

Fig. 14. *Callistochiton crassicostatus* Pilsbry. Exterior view of juvenile tail valve from same lot [515c]; same scale as preceding.

Fig. 15. *Callistochiton crassicostatus* Pilsbry. Right lateral view of same valve; same scale as preceding.

Fig. 16. *Callistochiton crassicostatus* Pilsbry. Interior view of same specimen; same scale as preceding.


1
1mm.
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1mm.
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11
12
1mm.
13
14
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16

Plate XIV.

Fig. 1. *Callistochiton decoratus punctocostatus* Pilsbry. Exterior view of head valve from Deadman Island, San Pedro, California (probably Pleistocene) [728].

Fig. 2. *Callistochiton decoratus punctocostatus* Pilsbry. Interior view of same valve; same scale as preceding.

Fig. 3. *Callistochiton decoratus punctocostatus* Pilsbry. Right lateral view of same valve; same scale as preceding.

Fig. 4. *Callistochiton decoratus punctocostatus* Pilsbry. Exterior view of tail valve from Deadman Island, San Pedro, California (probably Pleistocene) [715]; same scale as preceding.

Fig. 5. *Callistochiton decoratus punctocostatus* Pilsbry. Interior view of same valve; same scale as preceding.

Fig. 6. *Callistochiton decoratus punctocostatus* Pilsbry. Right lateral view of same valve; same scale as preceding.

Fig. 7. *Callistochiton decoratus ferminicus* Berry, n. subsp. Exterior view of type specimen, a median valve from the Chiton Bed, Point Fermin, California (Lower San Pedro Pleistocene) [1040]; same scale as preceding.

Fig. 8. *Callistochiton decoratus ferminicus* Berry, n. subsp. Anterior elevation of same valve; camera outline.

Fig. 9. *Callistochiton palmulatus mirabilis* Pilsbry. Dorsal view of head valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [522a]; same scale as Figs. 1-7.

Fig. 10. *Callistochiton palmulatus mirabilis* Pilsbry. Interior view of same valve; same scale as preceding.

Fig. 11. *Callistochiton palmulatus mirabilis* Pilsbry. Left lateral view of same valve; same scale as preceding.

Fig. 12. *Callistochiton palmulatus mirabilis* Pilsbry. Dorsal view of less mature head valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [522b]; same scale as preceding.

Fig. 13. *Callistochiton palmulatus mirabilis* Pilsbry. Interior view of same valve; same scale as preceding.

Fig. 14. *Callistochiton palmulatus mirabilis* Pilsbry. Left lateral view of same valve; same scale as preceding.

Fig. 15. *Callistochiton palmulatus mirabilis* Pilsbry. Exterior view of median valve from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [525]; same scale as preceding.

Fig. 16. *Callistochiton palmulatus mirabilis* Pilsbry. Interior view of same valve; same scale as preceding.


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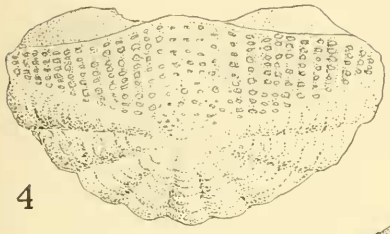
1mm.


2


3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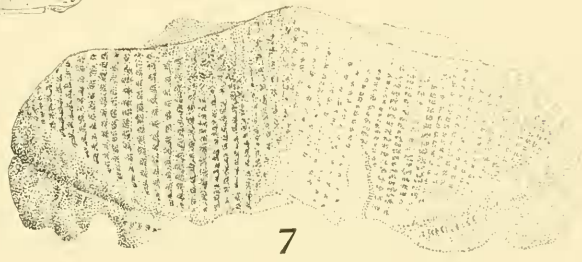
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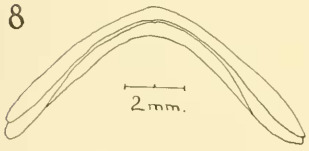
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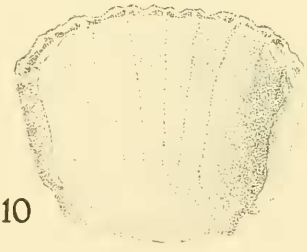
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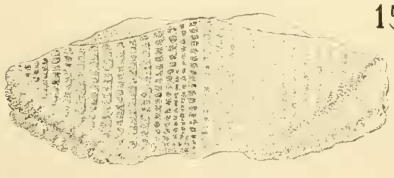
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16

Plate XV.

Figs. 1-6. *Callistochiton palmulatus mirabilis* Pilsbry. Dorsal aspect of six tail valves from Long Wharf Canyon, Santa Monica, California (Upper San Pedro Pleistocene) [528], showing variation at corresponding stages of growth.

Figs. 7-12. *Callistochiton palmulatus mirabilis* Pilsbry. Right lateral view of same six valves; same scale as preceding.

Fig. 13. *Callistochiton palmulatus mirabilis* Pilsbry. Interior view of valve shown in Figs. 1 and 7; same scale as preceding.

Fig. 14. *Callistochiton palmulatus mirabilis* Pilsbry. Interior view of valve shown in Figs. 4 and 10; same scale as preceding.